

DRAFT

Work Plan

For

Study Area Screening Evaluation

**Surface Warfare Officers School
Naval Station Newport
Newport, Rhode Island**



**Environmental Field Activity Northeast
Naval Facilities Engineering Command**

Contract Number N624767-94-D-0888

Contract Task Order 0842

April 2004



TETRA TECH NUS, INC.

WORK PLAN
FOR
STUDY AREA SCREENING EVALUATION

SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION NEWPORT
NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

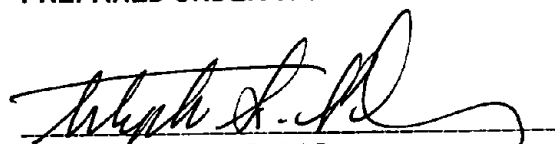
Submitted to:
Environmental Field Activity Northeast
Environmental Branch, Code EV2
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop No. 82
Lester, Pennsylvania 19113-2090

Submitted by:
Tetra Tech NUS, Inc.
600 Clark Avenue, Suite 3
King of Prussia, Pennsylvania 19406-1433

CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0842

April 2004

PREPARED UNDER THE DIRECTION OF:


STEPHEN PARKER, LSP
PROJECT MANAGER
TETRA TECH NUS, INC.
WILMINGTON, MASSACHUSETTS

APPROVED FOR SUBMISSION BY:

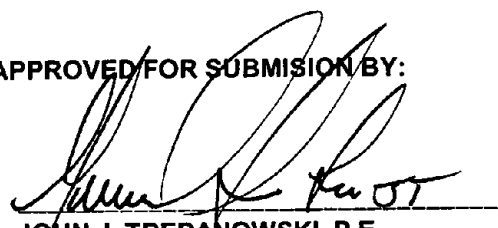

JOHN J. TREPANOWSKI, P.E.
PROGRAM MANAGER
TETRA TECH NUS, INC.
KING OF PRUSSIA, PENNSYLVANIA

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 INTRODUCTION.....	1-1
1.1 SITE-SPECIFIC INVESTIGATION OBJECTIVES.....	1-1
1.2 PROJECT ORGANIZATION AND RESPONSIBILITIES.....	1-2
1.3 PROJECT DELIVERABLES.....	1-4
1.4 WORK PLAN ORGANIZATION	1-5
1.5 CHANGES TO THE WORK PLAN.....	1-5
1.6 SCHEDULE AND REGULATORY OVERSIGHT	1-6
2.0 BACKGROUND INFORMATION.....	2-1
2.1 SITE LOCATION	2-1
2.2 SITE DESCRIPTION	2-1
2.3 PREVIOUS SITE INVESTIGATIONS AND HISTORY	2-5
2.4 GEOLOGY AND HYDROGEOLOGY	2-9
2.4.1 Regional Geology	2-9
2.4.2 Regional Hydrogeology.....	2-9
2.4.3 Site Geology and Hydrogeology	2-10
2.5 SITE WASTE CHARACTERISTICS.....	2-11
2.5.1 Potential Off-Site Contamination Sources	2-12
2.6 DATA QUALITY OBJECTIVES	2-14
2.6.1 Statement of the Problem.....	2-15
2.6.2 Identification of the Decision.....	2-15
2.6.3 Inputs to the Decision	2-15
2.6.4 Definition of the Study Boundaries.....	2-15
2.6.5 Decision Rule.....	2-16
2.6.6 Limits on Decision Errors.....	2-16
2.6.7 Design for Obtaining Data	2-17
3.0 FIELD INVESTIGATION AND SAMPLING PLAN.....	3-1
3.1 INTRODUCTION.....	3-1
3.2 TASK 1: RECONNAISSANCE SURVEY AND RECORDS SEARCH.....	3-1
3.3 TASK 2: GEOLOGIC/HYDROGEOLOGIC INVESTIGATION AND ENVIRONMENTAL SAMPLING	3-2
3.3.1 Advancement of Borings	3-3
3.3.2 Soil Sampling.....	3-7
3.3.3 Groundwater Monitoring Points	3-9
3.3.4 Well Development	3-13
3.3.5 Groundwater Sample Collection.....	3-14
3.4 TASK 3: LAND SURVEY	3-18
3.5 INVESTIGATION-DERIVED WASTE (IDW).....	3-18
3.5.1 Solid Wastes	3-19
3.5.2 Soil Wastes	3-19
3.5.3 Liquid Wastes.....	3-19
3.6 DECONTAMINATION PROCEDURES.....	3-20
4.0 QUALITY ASSURANCE/QUALITY CONTROL	4-1
4.1 PARCC PARAMETERS	4-2
4.1.1 Precision and Accuracy	4-2
4.1.2 Representativeness	4-2
4.1.3 Completeness.....	4-3
4.1.4 Comparability.....	4-4

TABLE OF CONTENTS (cont.)

<u>SECTION</u>		<u>PAGE</u>
4.2	QUALITY CONTROL SAMPLES.....	4-4
4.2.1	Field Duplicates	4-4
4.2.2	Rinsate Blanks.....	4-5
4.2.3	Source Blanks.....	4-5
4.2.4	Trip Blanks.....	4-5
4.2.5	Matrix Spike/Matrix Spike Duplicates	4-5
4.3	PROJECT ACTION LIMITS AND METHOD DETECTION LIMITS.....	4-6
4.4	SAMPLE DESIGNATION AND CUSTODY	4-7
4.4.1	Sample Numbering.....	4-7
4.4.2	Sample Chain of Custody.....	4-20
4.5	CALIBRATION PROCEDURES	4-20
4.6	LABORATORY ANALYSIS.....	4-21
4.7	DATA REDUCTION, REVIEW, AND REPORTING	4-21
4.8	INTERNAL QUALITY CONTROL.....	4-21
4.9	PERFORMANCE AND SYSTEM AUDITS	4-22
4.10	DATA ASSESSMENT PROCEDURES	4-22
4.10.1	Representativeness, Accuracy, and Precision	4-22
4.10.2	Data Validation.....	4-23
4.11	CORRECTIVE ACTION	4-23
4.12	DOCUMENTATION.....	4-24
5.0	REPORTING	5-1
5.1	SASE REPORT	5-1
5.2	HUMAN HEALTH RISK EVALUATION	5-2
6.0	REFERENCES	6-1

TABLES

<u>NUMBER</u>		<u>PAGE</u>
3-1	Proposed Field Samples	3-5
3-2	Well Installations/Soil Borings	3-6
3-3	Sample Container, Preservative, and Holding Time Requirements.....	3-10
3-4	Field Quality Control Sample Summary	3-11
4-1A	Soil - Volatile Organic Target Analytes, Method 8260B	4-8
4-1B	Soil - Semivolatile Organic Target Analytes, Method 8270	4-10
4-1C	Soil - Pesticides/PCB Target Analytes.....	4-12
4-1D	Soil - Inorganic Target Analytes Method 6010B and 6020	4-13
4-2A	Groundwater - Volatile Organic Target Analytes, Method 8260B.....	4-14
4-2B	Groundwater - Semivolatile Organic Target Analytes, Method 8270.....	4-16
4-2C	Groundwater - Pesticide/PCB Target Analytes, Method 8081/8082.....	4-18
4-2D	Groundwater - Inorganic Target Analytes.....	4-19

TABLE OF CONTENTS (cont.)

FIGURES

<u>NUMBER</u>		<u>PAGE</u>
2-1	Site Locus.....	2-2
2-2	NAVSTA Newport Sites and Study Areas	2-3
2-3	SWOS Location Map.....	2-4
2-4	Aerial Photograph - 1944.....	2-6
2-5	Aerial Photograph - 1962.....	2-7
2-6	Aerial Photograph - 1996.....	2-8
2-7	2003 Test Pitting and Soil Sampling Locations	2-13
3-1	Sample Locations.....	3-4

APPENDICES

- A Site Specific Health and Safety Plan
- B TtNUS Standard Operating Procedures
- C TtNUS Field Documentation Forms

1.0 INTRODUCTION

This work plan has been prepared under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62467-94-D-0888, Contract Task Order (CTO) 842. A Study Area Screening Evaluation (SASE) work plan for the Surface Warfare Officers School (SWOS) site, located at Naval Station Newport (NAVSTA Newport) in Middletown, Rhode Island is to be completed by Tetra Tech NUS, Inc. (TtNUS) on behalf of the Navy. This work plan outlines the requirements and describes the procedures for performing investigations at this site.

The purpose of this work plan is to describe the investigation necessary to characterize the nature and extent of environmental contamination at the SWOS site in order to prepare a SASE report in accordance with the Federal Facilities Interagency Agreement (FFA) between the United States Environmental Protection Agency (USEPA), the Rhode Island Department of Environmental Management (RIDEM) and the U.S. Navy for CERCLA Sites at NAVSTA Newport. Response action requirements under the Department of Defense Installation Restoration Program (IRP) at NAVSTA Newport are outlined in the FFA.

1.1 SITE-SPECIFIC INVESTIGATION OBJECTIVES

The project objective will address the nature and extent of contaminants present on the SWOS site as well as a possible relationship of this site to the adjacent Old Fire Fighting Training Area (OFFTA) site (Site 09). Specifically, the SASE will assess the presence of contamination in soils and groundwater through a focused investigation program.

The nature of the contamination at the SWOS site will be compared to pertinent state and federal criteria. A preliminary extent of contamination will be presented in the SASE report. In addition, a preliminary risk evaluation will be performed as is consistent with the scope of the SASE.

The SASE activities will include file reviews, background information research (aerial photographs, land use records, etc.), a site reconnaissance survey, advancement of soil borings and installation of micro wells, soil and groundwater sampling, laboratory analysis, surveying, and investigative derived waste removal. Details of these activities are provided in Section 3.0.

The scope of work for the SWOS SASE was developed based on information collected in support of the Phase I Environmental Site Assessment (TtNUS, 2001) and the Final Report and Risk Assessment for Workers Exposure at the SWOS Site (Foster Wheeler Environmental Corporation, 2003). Oily soils were encountered on the SWOS site during construction of the SWOS Applied Instruction Building. This

investigation is intended to document the presence of, and potential for, environmental contamination and risks to human health. The findings of this SASE will determine if subsequent investigations are necessary. The findings may be used in accordance with a subsequent Remedial Investigation, if one is deemed necessary, to evaluate remedial actions at the site through the performance of a feasibility study.

The objectives of this SASE are described in detail through the formulation of data quality objectives in Section 2.6 of this work plan.

1.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

TtNUS will be responsible for the overall management of the project, including the performance of field activities presented in this work plan.

NAVFAC personnel will be responsible for administrative and technical oversight of the program, project management and coordination between state or federal regulatory agencies, while the NAVSTA Newport on-site representative will be responsible for on-site coordination with TtNUS.

Key Navy personnel supporting this project are as follows:

- Curtis Frye, P.E., RPM
EFANE, NAVFAC
- Amanda Cerise, Facility Contact
NAVSTA, Public Works Department Environmental

Key TtNUS personnel supporting this project are as follows:

Tetra Tech NUS, Inc., Wilmington, MA

Phone: (978) 658-7899

FAX: (978) 658-7870

- Stephen Parker, L.S.P.
Project Manager
- Cynthia Woods
Human Health Risk Assessment

Tetra Tech NUS, Inc., Pittsburgh, PA

Phone: (412) 921-7090

FAX: (412) 921-4040

- Matt Soltis
TtNUS CLEAN Program Health and Safety Manager
- Paul Frank
TtNUS CLEAN Program Quality Assurance Manager
- Kelly Carper
TtNUS CLEAN Lead Chemist

The TtNUS Project Manager (PM) will have the primary responsibility for implementing and managing the SASE. The TtNUS Project Manager will also be responsible for notifying regulatory agencies of field activities or schedule modifications. A Field Operations Leader (FOL) and lead technical staff will be appointed to support the PM.

The CLEAN Health and Safety Manager is responsible for reviewing health and safety plans for all CLEAN operations, and performs site audits to ensure compliance with site health and safety requirements.

The Quality Assurance Manager is responsible for QA/QC requirements for the TtNUS CLEAN program. This individual reviews data and deliverable documents, and performs system audits to ensure contract QA/QC goals are met.

The Lead Chemist will advise the PM on technical requirements of the data and sample collection efforts. This individual will also assume a second role as site QA/QC officer.

A Lead Geologist will be appointed to direct technical work relating to the geologic and hydrogeologic investigations. The Lead Geologist will advise the PM on technical requirements relating to these tasks. Direction of certain subcontractors may be delegated from the FOL to the Lead Geologist (i.e. drilling). This individual will also coordinate the efforts of the field geologists with the FOL and the Project Manager to ensure the goals of the task are met.

The FOL will be responsible for directing on-site field activities and will report directly to the PM. The FOL will coordinate efforts of the field sampling staff, the subcontractors, and the lead technical staff.

The FOL will be responsible for identifying problem areas and bringing them to the attention of the PM for resolution.

A Site Safety Officer (SSO) will be designated prior to field activities and will be responsible for the adherence to all health and safety requirements. The SSO reports directly to the CLEAN Health and Safety Manager and the PM.

The Lead Risk Assessment personnel will be responsible for reviewing the sampling program to ensure it is adequate to meet the objectives of the study, for assimilation of the data into a format that is amenable to the manipulations that are required for risk evaluation, and for the performance of the risk evaluations.

In addition to the above personnel, TtNUS program personnel will provide overall support in subcontracting, cost tracking, progress reporting, and supervising the project manager. The program personnel include the following:

John Trepanowski, P.E.
Program Manager

Garth Glen
Deputy Program Manager

Tetra Tech NUS, Inc., King of Prussia, PA
Phone: (610) 491-9688
Fax: (610) 491-9647

1.3 PROJECT DELIVERABLES

Project deliverables submitted during this project will include:

- Internal Draft, Draft, and Final Work Plan for review
- Internal Draft, Draft, and Final SASE report.

A detailed description of the SASE report is presented in Section 5.0 of this work plan

1.4 WORK PLAN ORGANIZATION

Section 1.0, Introduction, of this work plan contains the site-specific investigation objectives, project and work plan objectives, and schedule.

Section 2.0, Background Information, describes the history of the site and the findings of previous investigations of both the site and the surrounding areas of possible concern.

Section 3.0, Field Investigation and Sampling, presents the field work required for this investigation. Tasks are listed in chronological order of execution. Sample collection procedures and analytical parameters are also described in this section.

Section 4.0, Quality Assurance/Quality Control, presents the Quality Assurance Plan for the SASE. This plan describes the QA/QC sample collection procedures and frequencies, data quality protocols, and analytical data validation requirements.

Section 5.0, Reporting, presents a brief description of the SASE report and human health risk evaluation that will be prepared following completion of all the field work described in Section 3.0 of this work plan.

Section 6.0 lists the references used in this work plan.

A site-specific Health and Safety Plan is attached as Appendix A. Appendix B presents Standard Operating Procedures (SOPs) for the field investigation work. Appendix C contains samples of forms to be used for documentation during this investigation.

1.5 CHANGES TO THE WORK PLAN

If, during the field investigation, the plan for collection of data needs to be altered, the work plan may be amended through the use of a Field Modification Request (FMR). This form will be prepared by the TtNUS FOL and forwarded to the TtNUS PM. The TtNUS PM makes a recommendation to the Navy RPM, who (if necessary) will forward the FMR to the regulatory oversight RPMs. Time limits on acceptance of, or comment to, the field modification requests will be stated. An example of this form is presented in Appendix C.

1.6 SCHEDULE AND REGULATORY OVERSIGHT

A schedule for field investigations has not been prepared at this time. However, several activities may warrant regulatory oversight. A schedule will be prepared and submitted to the USEPA and RIDEM upon development of a cost/schedule proposal to perform the field work. This schedule will be updated as necessary to inform oversight personnel when different tasks and activities are scheduled to occur.

Field sampling is planned to occur in a single phase effort. Any changes in the number or location of proposed soil borings or monitoring wells will be discussed with RIDEM and USEPA prior to initiation of the associated phase of fieldwork.

A 24-hour advance notification of changes in scheduled field activities will be given to the regulatory agencies.

2.0 BACKGROUND INFORMATION

The information provided in this section and some of Section 3.0 has been adapted from the Final Report and Risk Assessment for Worker Exposure at the SWOS Site (Foster Wheeler Environmental Corporation, 2003), Phase I Environmental Site Assessment for SWOS Building Site (TtNUS, 2001) and the Final Initial Assessment Study report (Envirodyne, 1983).

2.1 SITE LOCATION

NAVSTA Newport is located approximately 25 miles south of Providence, Rhode Island. Portions of the facility are located within the City of Newport and the Towns of Middletown and Portsmouth, Rhode Island. The facility occupies approximately 1,063 acres and the layout is long and narrow, following the western shoreline of Aquidneck Island for nearly 6 miles facing the east passage of Narragansett Bay.

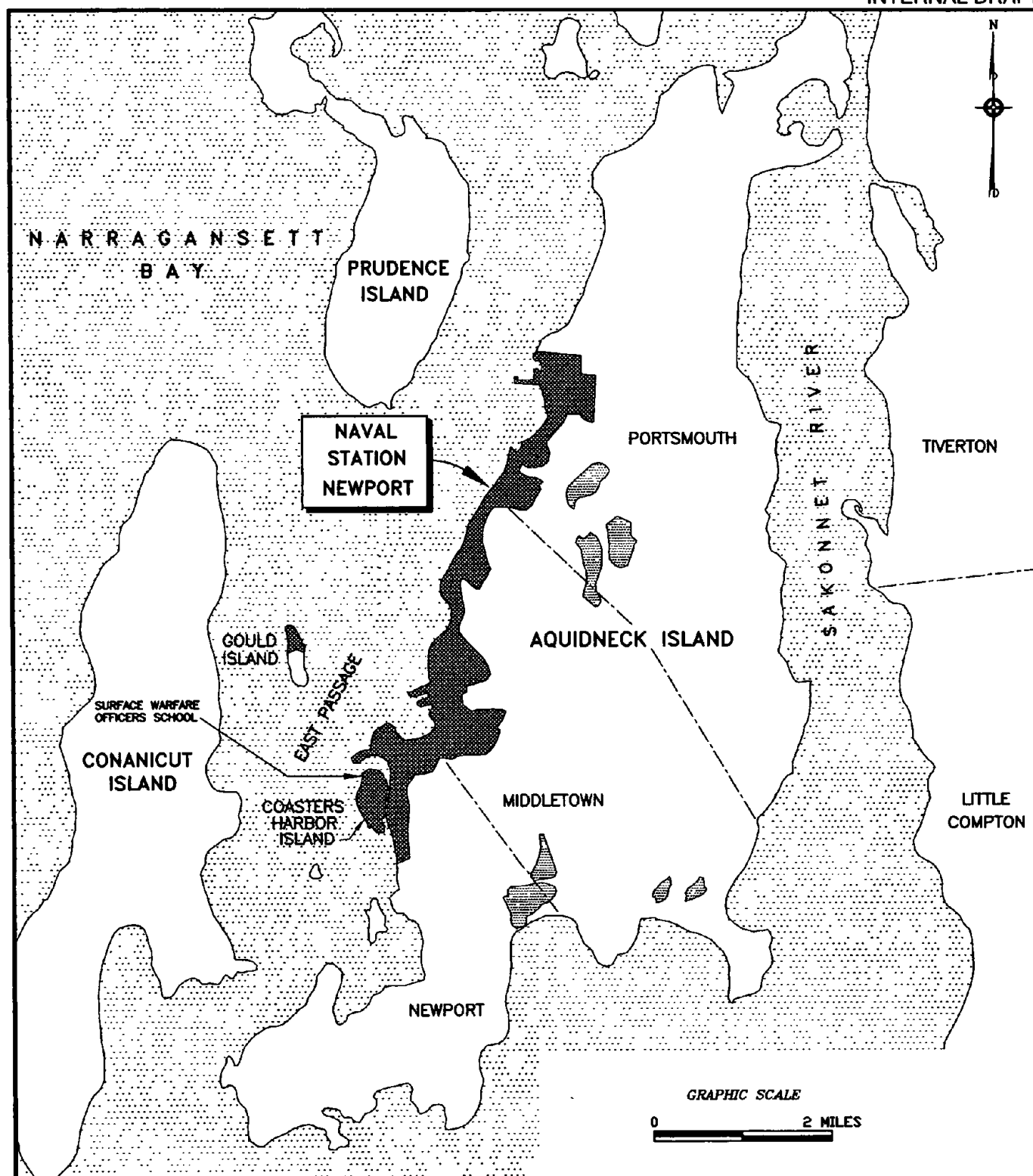
The Surface Warfare Officers School (SWOS) site (the site) is located on the northwestern end of Coasters Harbor Island at NAVSTA Newport. On Figure 2-1, the SWOS site is depicted in relation to the geographical extent of NAVSTA Newport. The location of the SWOS site, relative to other study areas within NAVSTA Newport, is shown on Figure 2-2. A map of Coasters Harbor Island showing the site location is provided on Figure 2-3.

As depicted on Figure 2-3, just north of the site is Taylor Drive and the Old Fire Fighting Training Area (OFFTA) site (Site 09). West of the site is Warfare Road, several buildings that make up the SWOS campus, and Narragansett Bay. South of the site is an open grass covered area, an asphalt parking lot and a number of buildings which comprise the Naval War College. The tennis courts and a gymnasium (Building 109) are located east of the site.

2.2 SITE DESCRIPTION

The site is the location of the former Brig facility at NAVSTA Newport. The building served as the correctional center (Brig facility) from its construction in 1951 until its demolition in 1996. When it was in use it was listed as Building 149 on NETC Plan No. 31490-311 prepared by Ames and Whitaker Architects (Ames and Whitaker, 1996).

The site occupies approximately 90,000 square feet. The SWOS Applied Instruction Building was constructed on site in 2003 and presently occupies an estimated 28,600 square feet, in the southwest corner of the site, adjacent to Warfare Road. Asphalt paved parking areas border the building to the north and east.



SITE LOCUS

FIGURE 2-1

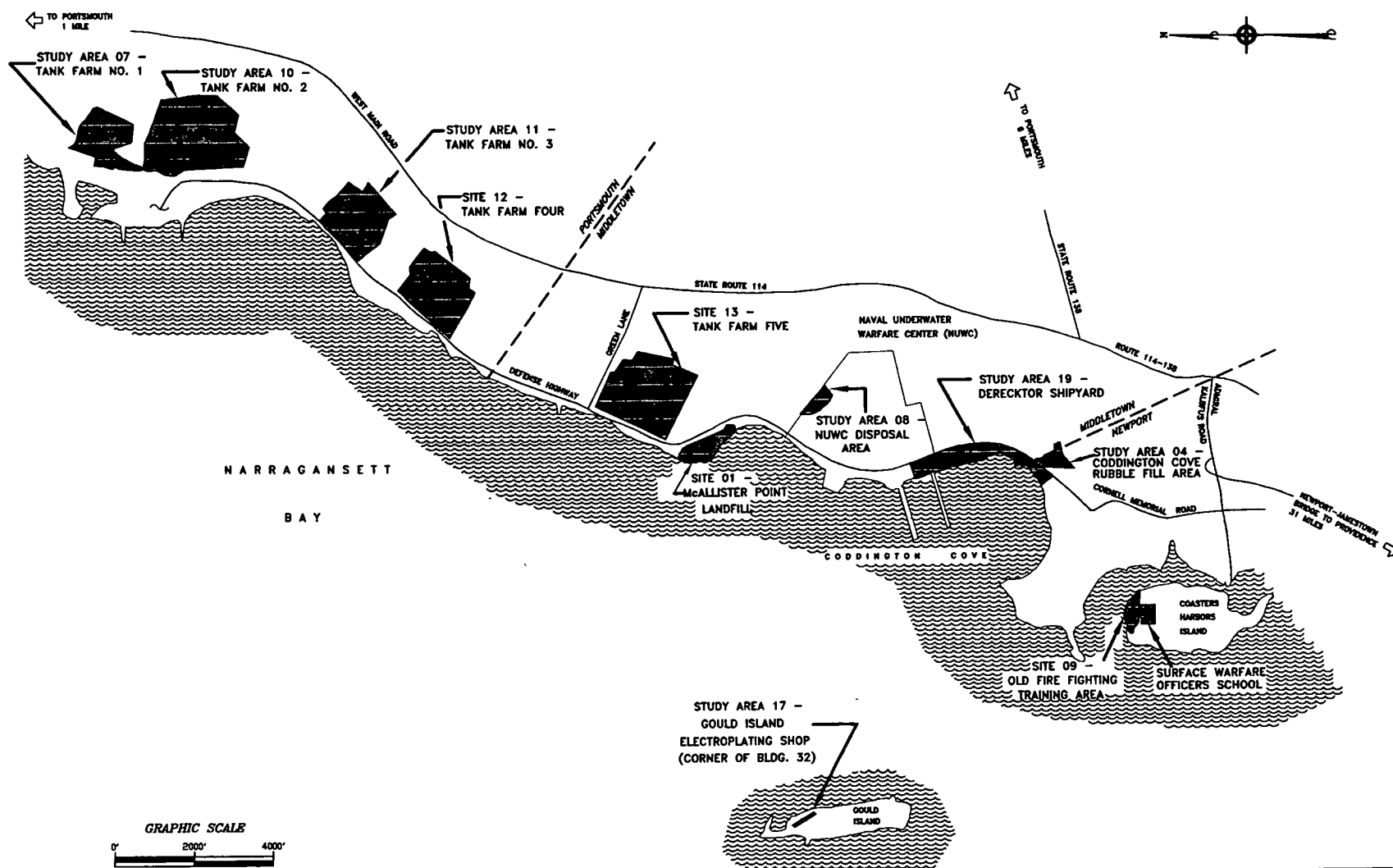
SURFACE WARFARE OFFICERS SCHOOL
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND

DRAWN BY:	D.W. MACDOUGALL	REV.	0
CHECKED BY:	L. SEYDEWITZ	DATE	MARCH 23, 2004
SCALE:	AS NOTED	ACAD NAME:	DWG\5152\0441\FIG_2-1 DWG



TETRA TECH NUS, INC.

55 Jonspin Road
 (978)658-7899
 Wilmington, MA 01887



NAVSTA NEWPORT SITES AND STUDY AREAS

SURFACE WARFARE OFFICERS SCHOOL

NAVSTA NEWPORT - NEWPORT, RHODE ISLAND

DRAWN BY:	D. W. MACDOUGALL	REV.:	0
CHECKED BY	L. SEYDEWITZ	DATE:	MARCH 23, 2004
SCALE	AS NOTED	FILE NO	DWG\5152\0441\FIG_2-2.DWG

FIGURE 2-2

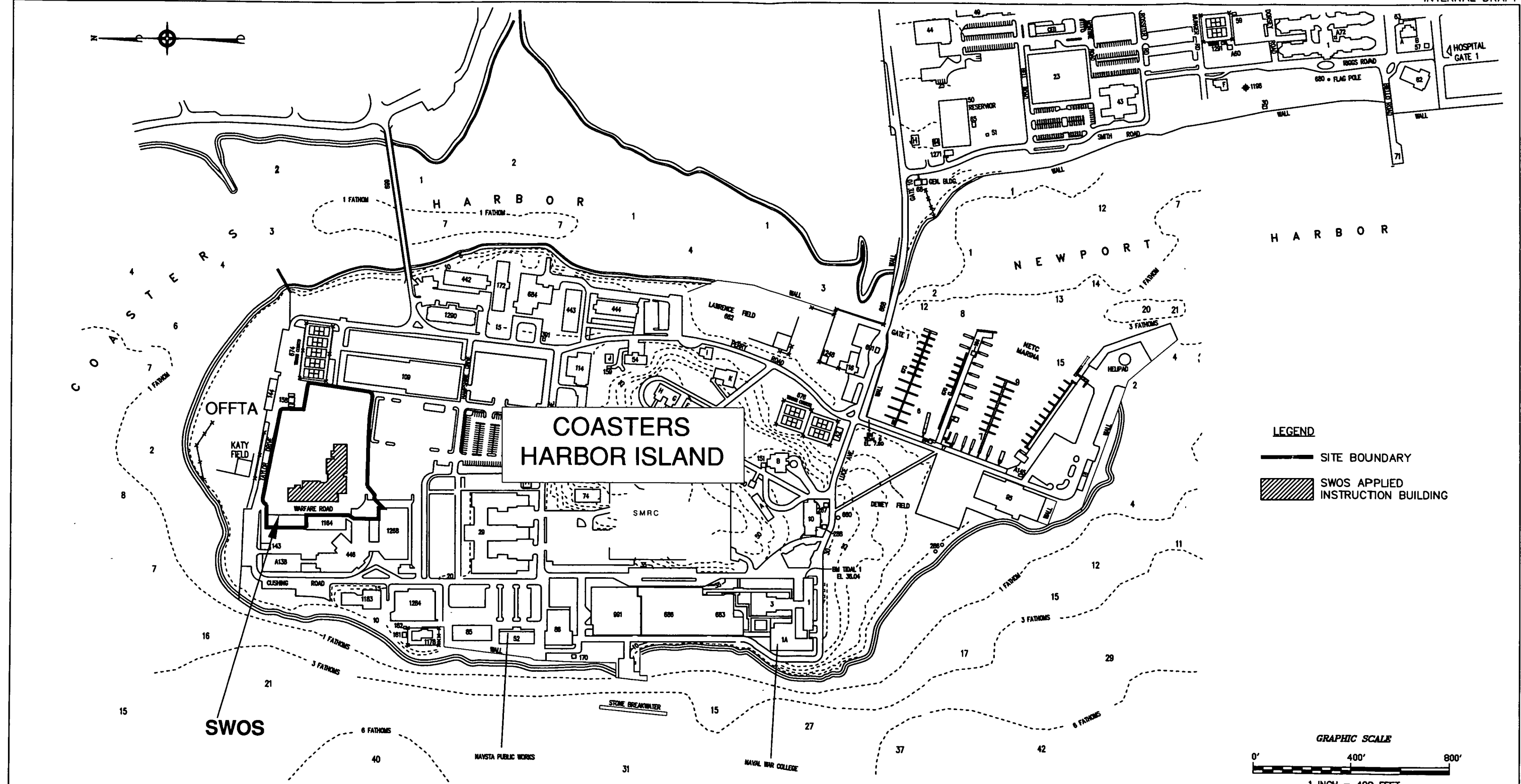


TETRA TECH NUS, INC.

55 Jonspin Road

Wilmington, MA 01887

(978)658-7899



NOTES:
BASE MAP FROM PLAN BY DEPT. OF NAVY, "COASTERS HARBOR ISLAND AND NAVAL HOSPITAL EXISTING CONDITIONS MAP", DATED: 9/58, NETC DWG NO.: 31058-307, CODE ID NO.: 80091, SCALE: 1"=200'.

NARRAGANSETT BAY

SWOS LOCATION MAP			
SURFACE WARFARE OFFICERS SCHOOL			
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND			
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	L. SEYDEWITZ	DATE:	APRIL 1, 2004
SCALE:	AS NOTED	FILE NO.:	DWG\5152\0441\FIG_2-3.DWG

FIGURE 2-3

TETRA TECH NUS, INC.

55 Jonspin Road
Wilmington, MA 01887
(978)658-7899

2.3 PREVIOUS SITE INVESTIGATIONS AND HISTORY

To date a limited investigation of the site has occurred. A Phase I Environmental Site Assessment for the SWOS Building Site was conducted in July 2001 (TtNUS, 2001). The Brig facility, referred to as the Correctional Center was previously located on the site as identified in the Final Initial Assessment Study (IAS) report (Envirodyne, 1983). The site was not reviewed under the IAS.

Aerial photographs of the site dating from 1944, 1951, 1962, 1992, 1996 and 1997 were reviewed. Figures 2-4, 2-5 and 2-6 present aerial photographs of the site in 1944, 1962 and 1996, respectively. The following is a summary of site observations obtained from the review of the aerial photographs:

The 1944 aerial photographs do not indicate evidence of activity in the vicinity of the site. The area is an open, partially grassy area with no trees or shrubbery present. The adjacent properties are developed and the roads are not paved.

Architectural plans show a facility, the Brig facility, was built in 1951 (TtNUS, 2001). As of October 1951 the facility was not present in the aerial photograph. The site was a vacant lot but shadowed areas adjacent to Warfare Road may indicate construction activity.

The facility is present in the 1962 photograph. The building takes up the majority of the site area. A paved parking lot is located directly east and another directly south of the building. Buildings border the site to the southeast and west. Structures are present at the OFFTA, north of the SWOS site.

The 1992 and 1996 aerial photographs do not indicate any significant change to the development of the SWOS site. The Brig facility is present. New building structures, parking lots and grassy areas adjacent to the site that were not present in the 1962 photograph are present in each of the 1992 and 1996 photographs. A new facility (Building 1164 and Building 446) and a paved parking lot border the site to the west. A paved parking lot borders the site to the south. A grass area borders the site to the east and According to the 1996 aerial photograph, the main structures at OFFTA have been removed and the site developed into a recreational area.

The Brig facility is no longer present in the 1997 aerial photograph. The lot is undeveloped and appears to have been leveled. There is no evidence of grass or other vegetation.

In summary, aerial photography confirms that prior to 1951, the site was undeveloped. Until its demolition in 1996/1997, the Brig facility was the primary structure on the site. Activities on the site appear to have been limited to the facility, and no connection to contamination at the OFFTA site was

SOURCE:

NS NEWPORT NEWPORT, RHODE ISLAND, RELEASE 4.1, JANUARY 2004

AERIAL PHOTOGRAPH - 1944

FIGURE 2-4

SURFACE WARFARE OFFICERS SCHOOL

NAVSTA NEWPORT - NEWPORT, RHODE ISLAND

DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	L. SEYDEWITZ	DATE:	APRIL 14, 2004
SCALE:	NONE	ACAD NAME:	DWG\5152\0441\1944.DWG



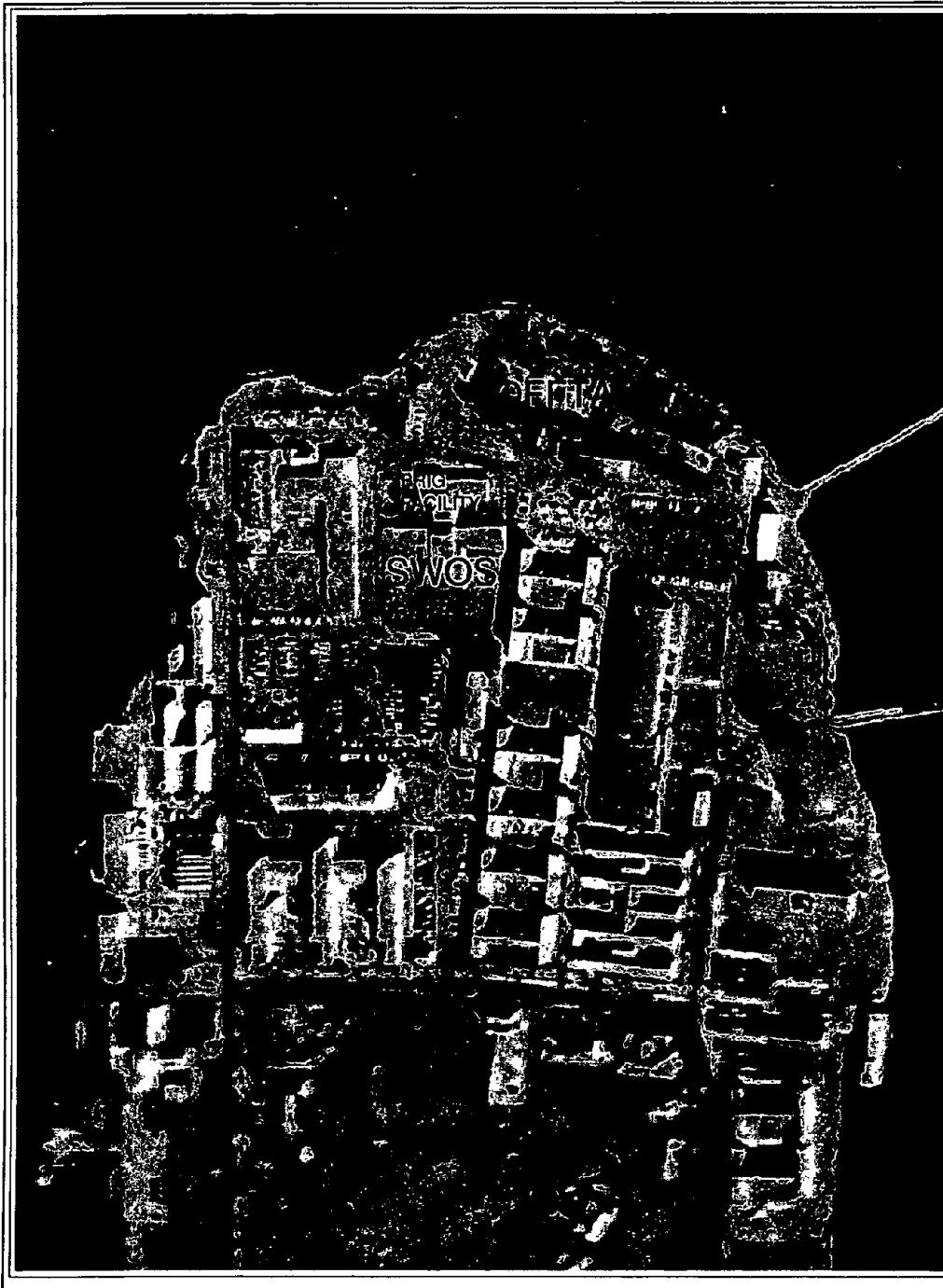
TETRA TECH NUS, INC.

55 Jonspin Road
Wilmington, MA 01887
(978)658-7899

W5204306D

2-6

CTO 842

SOURCE:

NS NEWPORT NEWPORT, RHODE ISLAND, RELEASE 4.1, JANUARY 2004

AERIAL PHOTOGRAPH — 1962

FIGURE 2-5

SURFACE WARFARE OFFICERS SCHOOL

NAVSTA NEWPORT — NEWPORT, RHODE ISLAND

DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	L. SEYDEWITZ	DATE:	APRIL 14, 2004
SCALE:	NONE	ACAD NAME:	DWG\5152\0441\1962.DWG

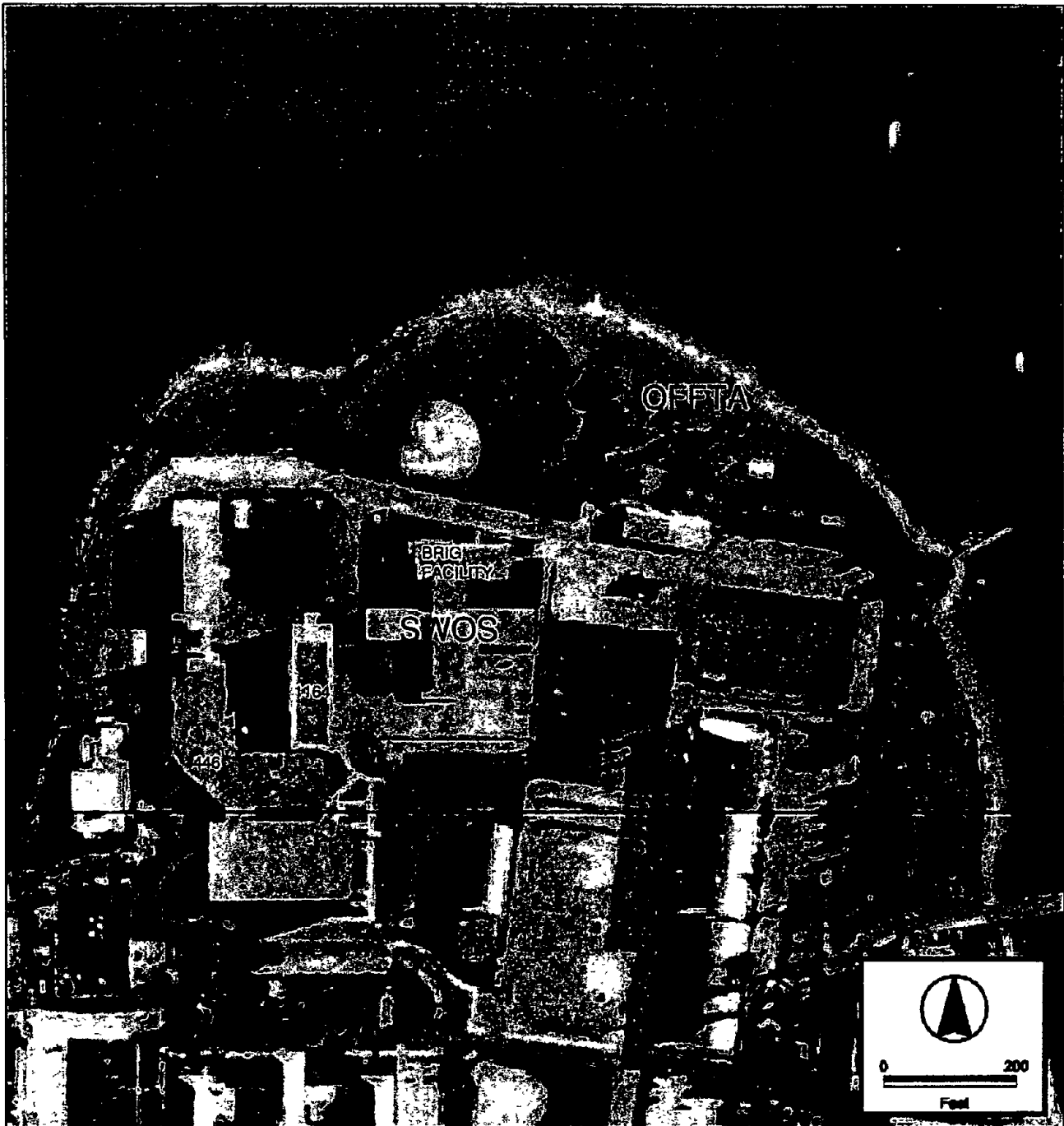


TETRA TECH NUS, INC.

55 Jonspin Road

Wilmington, MA 01887

(978)658-7899

SOURCE:

NS NEWPORT NEWPORT, RHODE ISLAND, RELEASE 4.1, JANUARY 2004

AERIAL PHOTOGRAPH – 1996

FIGURE 2-6

SURFACE WARFARE OFFICERS SCHOOL

NAVSTA NEWPORT – NEWPORT, RHODE ISLAND

DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	L. SEYDEWITZ	DATE:	APRIL 14, 2003
SCALE:	AS NOTED	ACAD NAME:	DWG\5152\0441\1996.DWG



TETRA TECH NUS, INC.

55 Jonspin Road

Wilmington, MA 01887

(978)658-7899

evident in the aerial photographs. The development of surrounding areas to the SWOS site are evident. Historic observations do not indicate evidence of activities that may have caused potential site contamination. Current site conditions are not represented in an available aerial photograph.

2.4 GEOLOGY AND HYDROGEOLOGY

This section presents a summary of the regional and site geologic and hydrogeologic features. This information is based on data from previously published literature and reports of other contractors.

2.4.1 Regional Geology

The NAVSTA Newport site is located at the southeastern end of the Narragansett Basin. The rocks of the Narragansett Basin are non-marine sedimentary rocks of Pennsylvanian age. The bedrock at the NAVSTA Newport facility is almost entirely of the Rhode Island Formation. A few areas of thick conglomerates are present within the Rhode Island Formation. They consist of pebbles, cobbles, and boulders interbedded with sandstone and graywacke. Coasters Harbor Island (Figure 2-3) is mostly covered with this conglomerate material. Overlying the Pennsylvanian rocks of the Narragansett Basin are surficial deposits of Pleistocene sediments. These unconsolidated, glacial sediments range in thickness from 1 to 150 feet and consist of till, sand, gravel, and silt.

2.4.2 Regional Hydrogeology

Many areas on Aquidneck Island, on which the NAVSTA Newport is located, obtain potable water from wells. Groundwater is obtained from the unconsolidated glacial till and outwash deposits, and from the underlying Pennsylvanian bedrock. The average depth to groundwater is 14 feet. In the NAVSTA Newport area, glacial till deposits are typically less than 20 feet thick. Well yields in these materials range from 1 to 120 gallons per minute. Although till is considered an unconsolidated deposit, the upper limit of this well yield is likely from an outwash deposit that is well sorted and stratified. Till wells typically yield a few hundred gallons of water per day, or less than 1 gallon per minute. Bedrock well yields range from less than 1 to as much as 55 gallons per minute and are highly dependent on the presence of joints and fractures. Most groundwater is soft or moderately hard. In scattered locations, pumping has led to salt water intrusion.

In the vicinity of NAVSTA Newport, groundwater flows generally from east to west, toward Narragansett Bay. The average depth to groundwater ranges between five and twenty feet below ground surface.

Area Water Use

Public water in the City of Newport and the town of Middletown is supplied and managed by the Newport Water Department. The Town of Portsmouth purchases water from the Newport Water Department, but operates its own distribution system. Approximately two-thirds of Portsmouth is serviced by public water while the remaining one-third is supplied by water from private wells. The majority of private wells are reportedly located on the eastern portion of Aquidneck Island.

The Newport Water Department receives its water supply from a series of seven surface water reservoirs located on Aquidneck Island and two surface water reservoirs on the mainland. Each of the reservoirs is supplied water via rainfall and runoff and is not augmented by groundwater supply wells. No surface water reservoirs are located on or downgradient from the site.

Groundwater Classification

RIDEM has classified groundwater in Rhode Island to protect and restore the quality of the State's groundwater resources for use as drinking water and other beneficial uses, and to assure protection of public health and welfare, and the environment. The groundwater at the site is classified by RIDEM as GB. Groundwater classified as GB is not suitable for use as a current or potential source of drinking water, as described in the Rhode Island Rules and Regulations for Groundwater Quality.

2.4.3 Site Geology and Hydrogeology

In preparation for the construction of the Brig facility, five pre-construction borings were advanced in 1951 at various locations at the site. The site's surficial geology reportedly consists of stratified layers of sand and gravel fill, "hard sand and gravel", "hard cemented sand and gravel", and shale. The thickness of the overburden deposits range from about 6 to 26 feet thick. The depth to groundwater ranges from approximately 4 to 6 feet below ground surface (NETC No. 11169-118, Cull and Robinson, 1951).

Based on geologic and hydrogeologic information attained during recent investigations at the OFFTA site, located directly north of SWOS, unconsolidated materials on the site are anticipated to consist of fill, including construction debris and sand and gravel; silty sand and gravel; sand and gravel; peat and silt; and glacial till, consisting of mixtures of silt, sand, and gravel (TtNUS, 2002).

The bedrock in this area of Coasters Harbor Island has been mapped and described as Purgatory Conglomerate. The bedrock may contain localized units of sandstone. In addition, the conglomerate is believed to be in contact with the Rhode Island Formation. In the southern portion of the Narragansett,

Basin, such as in the vicinity of NAVSTA Newport, the Rhode Island Formation is metamorphosed and consists of metaconglomerates and metasandstones, as well as schist, carbonaceous schist, phyllite, and graphite (TtNUS, 2002).

Groundwater elevations measured at OFFTA indicate that the groundwater flows toward Narragansett Bay and Coasters Harbor located north - northwest and east - northeast of the site, respectively (TtNUS, 2002). The proximity of SWOS to the OFFTA site may suggest that groundwater flow would be similar. The depth to groundwater ranges from 4 to 6 feet below ground surface (bgs) (NETC No. 11169-118, Cull and Robinson, 1951).

2.5 SITE WASTE CHARACTERISTICS

A number of potential hazardous waste sources are located on the site. Historically, transformers have been known to be sources of polychlorinated biphenyl (PCB) contamination. A transformer, located at the far northwestern corner of the site, was left intact during the demolition of the Brig facility. As of 1996, this transformer was in place and has the potential to be a source of PCB contamination if it leaks (NETC No. 31490-311; Ames and Whitaker, 1996). However, a site reconnaissance and research did not identify any leaks (TtNUS, 2001).

The old light fixtures used in the Brig facility are a possible source of PCBs. According to the 1996 Light Fixture Removal Plan, there were 258 light fixtures in the old Brig building. Of these, 50 light ballasts contained PCBs. A removal and disposal plan for these 50 light ballasts was established but no record confirming the outcome of these activities was located during the site records review (TtNUS, 2001). Documentation of proper disposal of these light fixtures would eliminate them as a possible source of contamination.

Asbestos-containing materials were located in the former Brig facility, including vinyl floor tiles and mastic, pipe and fitting insulation, glaze and frame caulk and duct flex. There was also an identified asbestos insulated pipe in the steam trench running from the south end of the Brig building to an adjacent manhole. Prior to the demolition of the building, an asbestos abatement was completed (NETC No. 31491-311; Ames and Whitaker, 1996). Asbestos containing materials have been eliminated and are not considered a possible source of contamination.

The interior and exterior paint on the former Brig facility was lead-based (NETC No. 31490-311; Ames and Whitaker, 1996). According to the 1996 demolition plans, the lead paint was to be removed prior to demolition and disposed of as a hazardous waste. Proper removal and disposal of the lead paint would

eliminate it as a potential source but there is no documentation of these activities based on a review of site records (TtNUS, 2001).

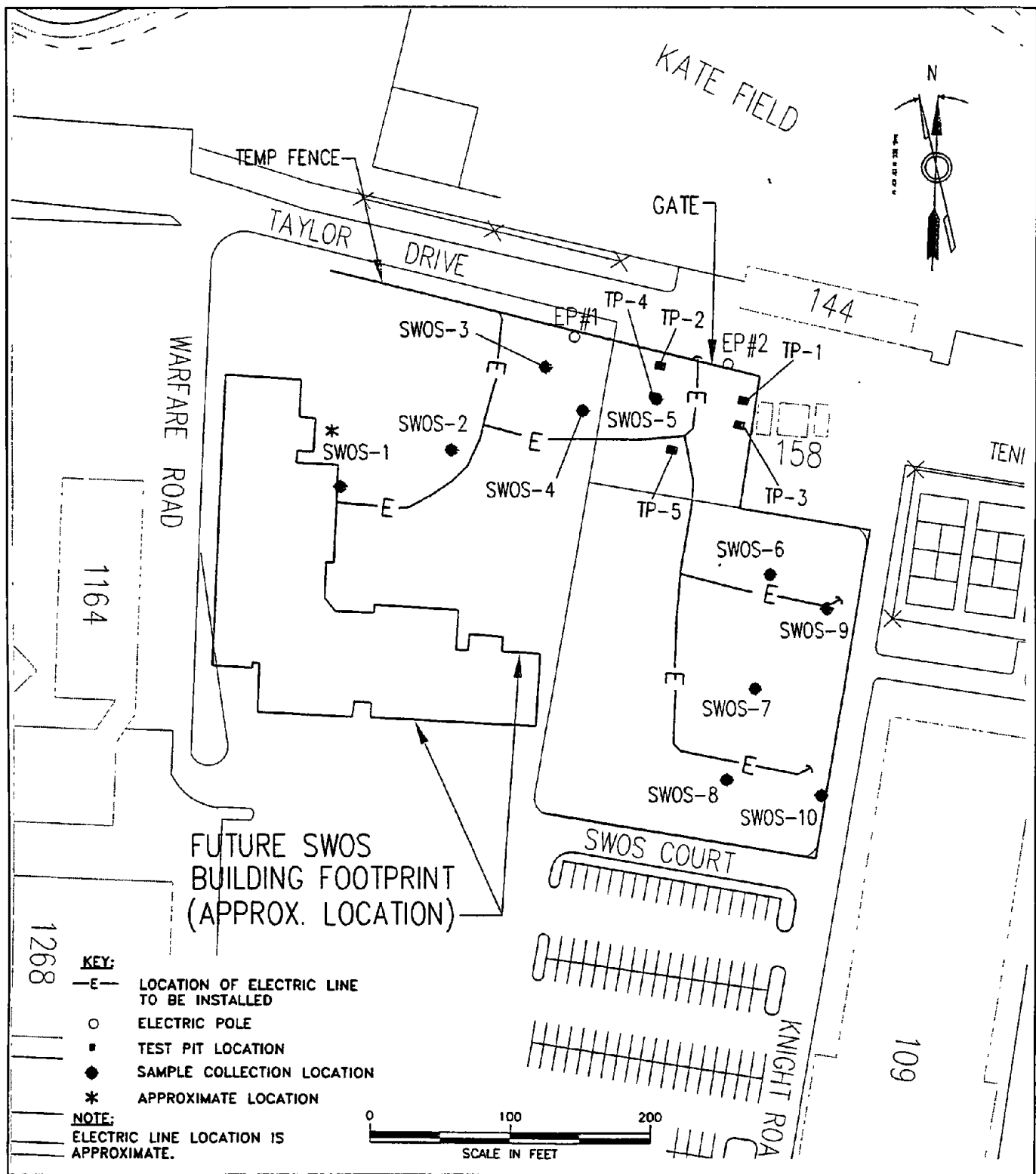
During soil excavation to install subsurface utility lines in support of the construction of the SWOS Applied Instruction Building, oily soils were discovered in areas adjacent to Taylor Drive. Soil sampling was conducted in May and July 2003 and a risk assessment performed to determine construction worker exposure risks during utility line installation and asphalt parking lot construction. All samples were analyzed for Target Analyte List (TAL) metals and Target Compound List (TCL) constituents (volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, and PCBs). The analytical results were compared to RIDEM Industrial/Commercial (I/C) Direct Exposure Criteria. One sample contained a lead concentration that exceeded the RIDEM I/C Criteria of 500 ppm and three samples contained Total Petroleum Hydrocarbon (TPH) concentrations that exceeded the RIDEM I/C Criteria of 2,500 ppm. The risk assessment calculated the construction worker hazard index (HI) to be 0.033, which is below the USEPA's Threshold HI of 1.0 and, therefore, is unlikely to be associated with adverse health effects (Foster Wheeler Environmental Corporation, 2003). Previous test pit and soil sample locations are shown on Figure 2-7.

There are no records indicating that underground storage tanks (USTs) were present at the former Brig facility or of Oil and Hazardous Material (OHM) storage at the facility. The former Brig facility was connected to the station sewer system (TtNUS, 2001). There is no identified septic waste disposal or hazardous material disposal area on the property (TtNUS, 2001).

2.5.1 Potential Off-Site Contamination Sources

There are several potential off-site contamination sources that may represent a threat of contamination to the site. A Remedial Investigation/Feasibility Study has been conducted at the OFFTA site (Site 09), located directly north of Taylor Drive and the SWOS site (see Figure 2-3). Analytical results presented in the Feasibility Study for the OFFTA site indicate that SVOCs, metals and one pesticide exceeded RIDEM Residential Direct Exposure Criteria for soil. For groundwater, one metal and one VOC exceeded the drinking water criteria at the site (TtNUS 2002).

Elevated arsenic concentrations are present at the OFFTA site. A Background Soil Investigation conducted for the OFFTA site states that the calculated background concentrations of arsenic at Coasters Harbor Island are believed to be attributable to the composition of the local and regional bedrock formations and the shallow depth to bedrock in the area (TtNUS, 2000). The potential presence of elevated arsenic in the surface and subsurface soils at the SWOS site would likely be attributed to natural background conditions since there has been no history of releases involving arsenic.



2003 TEST PITTING AND SOIL SAMPLING LOCATIONS

FIGURE 2-7

SURFACE WARFARE OFFICERS SCHOOL

NAVSTA NEWPORT — NEWPORT, RHODE ISLAND

DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	D. CHISHOLM	DATE:	APRIL 14, 2004
SCALE:	AS NOTED	ACAD NAME:	DWG\5152\0441\FIG_2-7.DWG



TETRA TECH NUS, INC.

55 Jonspin Road

Wilmington, MA 01887

(978)658-7899

Structure 74, was a double chamber tank, presumed to have contained heating oil, located approximately 1,000 feet south of the SWOS site, along the west coast of Coasters Harbor Island (see Figure 2-3). Historically, Structure 74 has been identified as a contamination source (RAD, 1999). There was a pump and treat system in place at the structure until the removal of both the building and the structure in 2002 (RAD; 1999). Groundwater from Structure 74 is assumed to flow directly to Narragansett Bay, making it unlikely that any contaminated groundwater from Structure 74 would migrate to the SWOS site. The tank has been cleaned and filled with foam, and the contamination remediated (TtNUS, 2001).

A District Public Works Office map dated December 1951, and titled "Pilot Plan and Location Plan: 75 Man Brig" (NETC No. 11169-118; Cull and Robinson, 1951), depicts two potential sources of contamination in the vicinity of the Brig facility. A transformer vault, labeled Building 84, was located approximately 800 feet southwest and hydrologically upgradient of the site. An area labeled "fuel tanks" was located approximately 400 feet directly west of the south corner of the Brig building, behind Building 138. Recent maps do not depict either of these structures, indicating that they may have been closed and no longer exist (NETC No. 31491-311; Ames and Whitaker, 1996).

Potential off-site contamination sources do not appear to represent a significant threat of contamination to the site. Groundwater contamination associated with Structure 74 has been remediated and the tank removed, while Building 84 and the "fuel tanks" identified on a map in 1951 are no longer present. The presence of elevated arsenic levels are likely at the SWOS site but can be attributed to the widespread presence of elevated arsenic concentrations throughout Coasters Harbor Island.

2.6 DATA QUALITY OBJECTIVES

The data quality objectives (DQOs) for this project were developed in accordance with the EPA Guidance for Data Quality Objectives (EPA G4 document). The G4 document suggests seven steps be followed to develop project DQOs. The objectives are somewhat previously established by CERCLA guidance, the Federal Facilities Agreement, and other standard guidelines for the performance of SASE's. The intended use of the data resulting from a field investigation is a determining factor in defining the DQO for that data. To be certain that the data is consistent with the goals of the investigation, the seven steps of defining DQOs is suggested.

The seven steps are described in the following subsections:

2.6.1 Statement of the Problem

During construction of the SWOS building at NAVSTA Newport, oil was encountered in the ground at concentrations exceeding RIDEM criteria. Other contaminants may exist, as there is little record of historical activities at this site.

The investigation will identify contaminants present on the SWOS site and whether those contaminants represent a threat of contamination to the soil and groundwater proximal to the site. The possible relationship of the SWOS site to the adjacent OFFTA site will be discussed, based on the data collected, and a preliminary risk evaluation will be performed. The findings of this SASE will determine if subsequent investigations are necessary and the extent thereof.

2.6.2 Identification of the Decision

After the completion of this study, a decision will be made as to whether there will be a need for additional studies and actions under the CERCLA process. This decision will be based on the potential for risk to receptors identified as a part of this SASE. If there is a defined potential for risks of adverse effects to receptors from site-related contaminants, additional steps in the CERCLA process will be followed, quantifying that risk and then moving forward with a feasibility study. *Or no risk = stop.*

2.6.3 Inputs to the Decision

Inputs to the decision are the elements used in the decision process. Inputs to the decision as stated in Section 2.6.2 are as follows:

- Concentrations of the contaminants present
- Toxicity of contaminants
- Presence of potential receptors
- Presence of complete exposure pathways to the potential receptors, in the present or wider potential future use conditions of the site
- USEPA and RIDEM recommended standards for determining adverse exposure

2.6.4 Definition of the Study Boundaries

Study boundaries can be physical and temporal. This section defines the boundaries and the rationale for their selection.

The problem stated in Section 2.6.1 focuses on the entire SWOS site. Although other contaminant sources may be present upgradient or adjacent to the site that may result in the deposition of contaminants at the site, the study shall remain focused on identification of contaminants within the site and how those contaminants may impact receptors. The study will evaluate the soil and groundwater at the site.

Temporal boundaries will be limited to the current exposure and potentially associated risk as evaluated from contaminants now present. In addition, the potential for future exposure pathways and risk will be evaluated.

Exposure scenarios for the current and future use will be industrial/commercial. Access to the property is currently only available to NAVSTA Newport employees and SWOS students.

During the field investigations, the field personnel on site will note the use of the site by any persons other than NAVSTA Newport employees or SWOS students who are designated to be in the area. If children are observed at the site, or if there is evidence present that of children trespass present at the site, the inclusion of a child trespasser in any future risk assessment tiers will be evaluated.

2.6.5 Decision Rule

The decision rule is a clear statement defining the requirements of the investigation based on the possible outcomes of the study. For this work plan, the decision rule shall be as follows:

- If the human health risk evaluation indicates there is a reasonable probability for adverse human health effects as defined by USEPA and RIDEM regulations, then further steps in the CERCLA process will have to be taken to define the extent of contamination, and quantify risk to receptors present.

If no health risk, then stop.

2.6.6 Limits on Decision Errors

The limits of decision errors are set to quantify the potential for false negative and false positive decisions. As a SASE, this study requires a low potential for a false negative decision. This means deciding not to go forward with CERCLA actions when in fact the risk defined in the Decision Rule does exist and actions should be taken. Conversely, a somewhat higher tolerance for a false positive decision is acceptable for this stage, since the resulting effect would be to carry the process as far as the feasibility study when it is not warranted. A separate decision rule would be set for a cleanup action as a part of the Record of Decision (ROD).

Conservatism in the process for the assessment of risks will decrease the potential for a false negative decision but not overly increase potential for a false positive decision. This conservatism is applied with exposure scenarios and other parameters used to measure exposure. This conservatism is furthered by evaluating the reasonable worst-case scenario for exposure using the maximum concentrations detected. Average concentrations are also used in the risk assessments in order to have some manner of comparison.

2.6.7 Design for Obtaining Data

The DQO process described in the G4 DQO document describes the use of various statistical approaches for development of a database. These are typically based on the representativeness of the data that are required. For instance, if the Decision Rule was to "remove soils with concentrations of lead above 10 mg/kg", the sampling plan would be based on the capability for identification of hot spots of a predetermined size, which would be the basis for precision on the removal action to be taken.

However, given the goals of this investigation, the design of the sampling plan can be more qualitative. The sampling plan is provided in Section 3 of this work plan. Samples will be collected to measure concentrations of contaminants present to which human receptors may be exposed.

Sample media for this site will include surface soils, subsurface soils, and groundwater at and near the areas of suspected impact. This approach will allow the investigators to determine the "extent of contamination" if a remedial investigation is required under CERCLA.

Specifics on the precision, accuracy, representativeness, etc. of the data collected are described in the Quality Assurance Project Plan, presented in Section 4 of this work plan. These are established standards for Remedial Investigations under the CERCLA process. Use of these standards will allow the use of the data collected as a part of this study in a Remedial Investigation if one is required at a later date.

3.0 FIELD INVESTIGATION AND SAMPLING PLAN

The following sections detail the field activities to be performed during this investigation. Specific TtNUS Standard Operating Procedures (SOPs) will be referenced where applicable. The analytical laboratory has not been identified at this time. Once selected, laboratory SOPs will be maintained as part of the administrative record.

3.1 INTRODUCTION

The focus of the Field Sampling Plan (FSP) is to assess and evaluate site conditions in order to obtain adequate data to support the SASE report and the human health risk evaluation. The objectives are to:

- Characterize the waste materials that may exist at the SWOS site and determine the preliminary extent of hazardous materials released to the environment.
- Determine the type of contamination associated with releases (if any) from the use and subsequent demolition of the Brig facility.
- Identify contaminants that may exist on site.
- Collect samples for full TCL organics (including VOCs, SVOCs, and pesticides/PCBs), gas range organics/diesel range organics (GRO/DRO), TAL metals and dissolved metals analyses to support the data needs of the human health risk evaluation.

The data collected during these investigations must be capable of supporting these assessments. The content of the report and the assessments is described in Section 5.0 of this work plan.

The field investigation will consist of three tasks including: 1) a reconnaissance survey and records search, 2) a geologic/hydrogeologic investigation and environmental sampling, and 3) a land survey. The details of each task are described in the following sections.

3.2 TASK 1: RECONNAISSANCE SURVEY AND RECORDS SEARCH

Access to the study area is restricted. The NAVSTA Newport facility including the SWOS site is completely fenced and guarded. Prior to any on-site work activities, security passes will be required for all TtNUS and subcontractor personnel while working in the study area. Security passes will be obtained through coordination with NAVSTA Newport contacts.

A site walkover will be conducted by the TtNUS field sampling team members to familiarize themselves with site conditions. The site will be reviewed with respect to access restrictions and sampling locations. Site-specific health and safety considerations, including emergency evacuation procedures, will be reviewed. Pertinent features, such as any overhead and subsurface utilities, and other potential hazards will be reviewed with Navy personnel with respect to planned sampling activities.

In addition to the planned field activities, a new records search will be conducted for documentation of the planned removals and abatement which occurred before and after the demolition of the Brig facility. The records search will include a search and review of RIDEM, Navy, and TtNUS data sources. An attempt will also be made to locate and interview naval personnel at the base who may have been associated with prior activities at the site.

3.3 TASK 2: GEOLOGIC/HYDROGEOLOGIC INVESTIGATION AND ENVIRONMENTAL SAMPLING

The objective of this task is to evaluate the presence of soil and groundwater contamination resulting from historical on-site or potentially off-site activities. Chemical data will be collected to assist in making preliminary determinations on the presence of contaminants in the two media. The data will be used to prepare the human health risk assessment.

The scope of work for the geologic/hydrogeologic and sampling investigation includes the following specific components:

- Characterization of a possible water table aquifer.
- Initial characterization of overburden soils and bedrock.
- Collection and evaluation of groundwater quality data at background locations.
- Assessment of the nature and distribution of groundwater contamination at the site.
- Additional characterization of contaminant migration pathways, including presence of permeable soils and features associated with surface water runoff, such as underground drainage systems.

The subsurface exploration program will address the areas of concern identified in the Phase I Environmental Site Assessment (TtNUS, 2001) and more recently, the Final Report and Risk Assessment for Worker Exposure at the SWOS Site (Foster Wheeler Environmental Corporation, 2002). Specifically, the sampling program will be expanded to adequately characterize areas of contamination encountered during the construction of the SWOS Applied Instruction Building. One background boring and one background micro well will also be installed as a part of this investigation. Proposed boring/micro well locations are presented on Figure 3-1 of this work plan. The proposed field samples are presented on Table 3-1.

Twenty (20) test borings are planned in the study area to investigate potential releases of contamination to soils, characterize subsurface lithology, and for the installation of five (5) micro wells (UW01 through UW05, Table 3-2). Table 3-2 describes the location, the proposed screen interval, and the purpose of each of the wells to be installed.

The planned soil boring locations may be reassessed based upon any observed evidence of gross contamination or staining which could indicate the presence of high concentrations of contaminants that may be leaching into the groundwater. If drums or other evidence of gross contamination are discovered, the wells may be moved and placed in the area(s) to determine partial impacts on the shallow overburden aquifer.

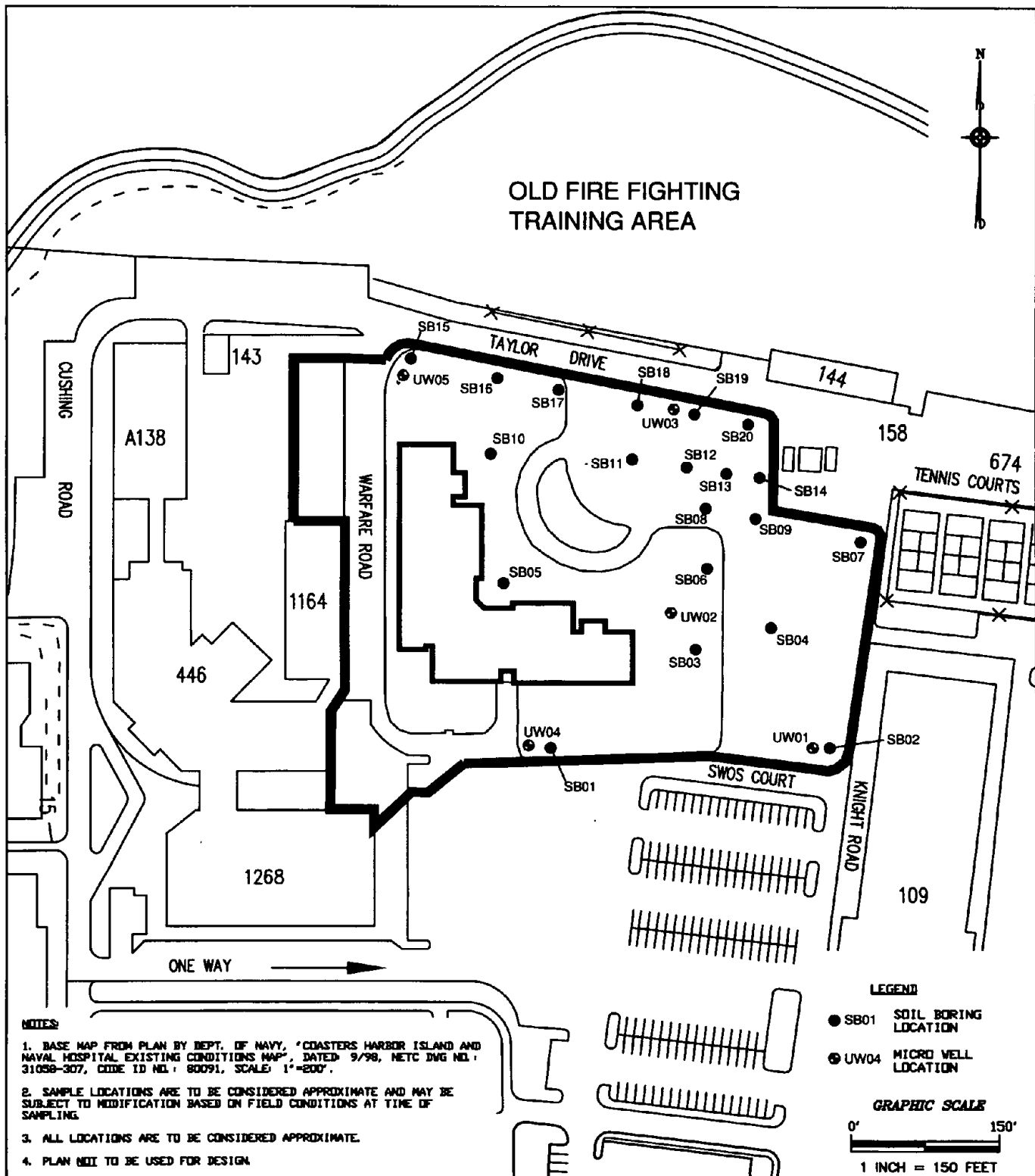
Proposed changes in the location or in the number of borings/wells will be discussed with RIDEM and EPA prior to actual field operations, and if a change is warranted, the regulatory parties shall also be notified using a Field Modification Request, as described in Section 1.5 of this work plan.

3.3.1 Advancement of Borings

A total of 20 soil borings will be advanced using Direct Push Technology (DPT). The drilling apparatus uses Macro-Core® samplers fitted with detachable aluminum or steel drive points that are driven into the ground using hydraulic pressure. The specific equipment used will be determined based on field conditions and the expected use of the borehole.

The soil borings will be advanced following general procedures specified in TtNUS SOP No. SA-2.5. Soil cores will be collected in an acetate sleeve in two-to-four-foot lengths. Soils will be described according to the Unified Soil Classification System, and logged to provide a complete lithologic record of the subsurface materials. As each acetate sleeve is opened, the soils will be monitored for organic vapors by scanning the soils using the flame ionization detector (FID) monitoring instrument and the photoionization detector (PID). The breathing zone of both the drillers and samplers will be periodically monitored for organic vapors, in accordance with the site specific Health and Safety Plan (Appendix A).

Soil borings will be advanced to 5 feet below the top of the saturated zone or to bedrock, as determined by the rig geologist. Depth to bedrock is estimated to be 8 feet below ground surface (bgs). If refusal is encountered before 8 feet bgs, up to two more attempts will be made. If bedrock is not encountered



SAMPLE LOCATIONS

FIGURE 3-1

SURFACE WARFARE OFFICERS SCHOOL

NAVSTA NEWPORT — NEWPORT, RHODE ISLAND

DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	L. SEYDEWITZ	DATE:	APRIL 1, 2004
SCALE:	1" = 150'	ACAD NAME:	DWG\5152\0441\FIG_3-1.DWG



TETRA TECH NUS, INC.

55 Jonspin Road

Wilmington, MA 01887

(978)658-7899

TABLE 3-1
 PROPOSED FIELD SAMPLES
 DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
 SURFACE WARFARE OFFICERS SCHOOL
 NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

ACTIVITY	MEDIA	NUMBER OF SAMPLES			
		TCL VOCs and Percent Moisture	TCL SVOCs ⁽¹⁾	TAL Metals	GRO/DRO (8015B Modified) ⁽³⁾
Geologic/Hydrogeologic Investigation	Soil	40	40	40	40
	Groundwater	5	5	5	5
	Total ⁽²⁾	45	45	45	45

⁽¹⁾ SVOC parameters include TCL base, neutral and acid extractable compounds, and pesticides and PCBs

⁽²⁾ Proposed field sample totals do not include quality control samples.

⁽³⁾ Method 8015 Modified for Extractable TPH, C9-C36 Hydrocarbon by G.C.

TABLE 3-2
WELL INSTALLATIONS/SOIL BORINGS
DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
SURFACE WARFARE OFFICERS SCHOOL
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

WELL/BORING NUMBER	LOCATION	WELL SCREEN INTERVAL	PURPOSE OF WELL
UW01 (upgradient location)	Southeast of the site in an anticipated hydrologically upgradient area and adjacent to SB02 (Refer to Figure 3-1)	Unconsolidated overburden based on field screening and soil conditions	Establish background groundwater quality in overburden.
UW02	Central portion of the site, east of the SWOS Applied Instruction Building	Unconsolidated overburden, based on field screening and soil conditions	Assess impacts of site contaminants on groundwater quality in overburden.
UW03	Northeast corner of the site, adjacent to SB19	Unconsolidated overburden, based on field screening and soil conditions	Assess contaminants present in groundwater at or immediately downgradient of area of observed contamination.
UW04	Southern extent of the site, adjacent to the south (paved) entrance area and SB01	Unconsolidated overburden, based on field screening and soil conditions	Assess impacts of contaminants on groundwater quality in overburden.
UW05	Northwest corner of the site, adjacent to SB15	Unconsolidated overburden, based on field screening and soil conditions	Assess downgradient impacts of contaminant releases on groundwater in overburden.
SB01-SB20	(Refer to Figure 3-1)	N/A	Assess impacts of site contaminants on soil quality.

within 5 feet of the water table, one boring will be advanced to bedrock. If the water table is not encountered before reaching bedrock, up to three attempts will be made to penetrate the bedrock to find the water table. If evidence of contamination exists at the bedrock overburden interface, the Navy will review the need for bedrock borings/wells.

A log of each borehole will be maintained by the field geologist to describe lithologies encountered, depth of geologic contacts, water levels, sample depths, bedrock characteristics, and any other pertinent observations made during drilling. Boring logs will also include information on sample number, type, and depth; and sample interval and recovery. An example boring log is included in Appendix D of this work plan.

Any drill cuttings will be containerized and sampled for waste characterization, as described in Section 3.9. Decontamination of sampling equipment and drilling apparatus will be performed as described in Section 3.10.

3.3.2 Soil Sampling

A total of 40 soil samples will be collected from the 20 DPT borings. Two soil samples, one from the 0 to 1-foot interval and one from the two-foot interval, just above the groundwater table (soil saturation as determined in the field) will be collected from each of the soil boring locations listed above. If signs of potential contamination (e.g., odors, stains, sludges) are observed at a depth between the two planned sampling intervals, the second sample will instead be collected from the depth of greatest observed contamination (i.e., most stained or highest headspace screening results) below the surface interval. VOC headspace screening will be performed on each sample using a FID as well as a PID. The jar headspace screening method is presented in Appendix B of this work plan.

The sample from each interval will be treated as separate samples. Aliquots of the material for VOC and GRO analyses will initially be collected using a cut syringe or equivalent device and placed in pre-preserved vials with septa caps, according to SW846 Method 5035A, July 2002.

The soil samples to be analyzed for VOCs and GRO will be preserved by immersion in reagent grade water and placed in a freezer, immediately after collection. The holding time from sample collection to analysis if samples remain frozen is 14 days. If samples are not frozen, the holding time is only 48 hours. The following procedure should be followed:

1. Label four pre-tare weighed 40-ml amber vials containing reagent grade water with the sample location number and a bottle letter such as A, B, etc. (two for the VOC analysis and two for the GRO analysis).
2. Collect approximately 5 grams of material by coring or stabbing the soil or sediment with a 10-ml pre-cut syringe. Extrude the sample into one of the 40-ml VOC vials containing 5 ml of reagent grade water. The soil must be immersed in the water; recollect the sample using a smaller volume if necessary. Avoid touching the threads on the vial's neck or loss of water by evaporation. Cap the vial and invert it several times to mix the sample.
3. Weigh the sample vial again to the nearest 0.01 g and record the weight in the field log sheet. Repeat the procedure with the other vial(s). Pack and ship to the laboratory. Include the field log sheet containing the sample weight information. One in every 20 samples should be assigned as a laboratory matrix spike/matrix spike duplicate. For this sample, collect three of the vials for each analysis.

Soil Sample For Percent Moisture Fill one 2-oz. container with soil or sediment from the same location that the samples for VOC analysis were collected.

Every effort should be made to collect multiple cores of soil for the low level procedure, and the percent moisture as close to one another as possible in each sample interval to obtain precise results.

Duplicate samples will be collected from the subsurface soils. Following the collection of the first set of VOC and GRO containers, collect the field duplicate set from the same sampling interval.

Collect field duplicates and assign the matrix spike/matrix spike duplicate from different locations.

After the VOCs and GRO are collected, the remaining material in the open acetate sleeve will be placed into a decontaminated stainless steel bowl and homogenized with a decontaminated stainless steel trowel, disposable scoop, or similar device. After mixing to homogenize the sample, aliquots will be removed for analysis of TCL SVOCs, pesticides/PCBs, TAL metals, and DRO. A summary of the sampling and analytical parameters is provided in Table 3-1. The sample containers for the different analytical parameters should be filled in the following order: VOCs/GRO/percent moisture, SVOCs, pesticide/PCBs, metals, and DRO.

Samples will be designated as the soil boring designation (SB##), and depth intervals will be expressed in feet. For example, sample SWOS-S-SB05-0204 indicates a soil sample from the boring for SB05,

2 feet to 4 feet below ground surface. Details of sample designations are presented in Section 4.4 of this work plan.

Appropriate chain-of-custody procedures will be followed (see Section 4.4.2) and samples will be labeled, packaged and shipped according to TtNUS SOP No. SA-6.1. Required analytical methods, sample preservation requirements, required sample containers, and Data Quality Levels are provided in Table 3-3. Table 3-4 summarizes the quality control samples to be collected and analyzed. Decontamination of sampling equipment is summarized in Section 3.6.

3.3.3 Groundwater Monitoring Points

As part of the assessment of the nature and distribution of contaminants in groundwater, micro wells will be installed and a sampling program conducted. This program includes installation of five micro wells in addition to the 20 DPT borings. The proposed location of each well installation is presented on Figure 3-1. The purpose of each installation is presented in Table 3-2.

Four micro well locations (UW02 through UW05) have been selected to evaluate potential releases of site related contamination to groundwater. One additional location (UW01) represents a micro well installed hydraulically upgradient of the SWOS site to establish background groundwater quality conditions in the overburden.

The micro wells are planned in the following locations: one overburden well toward the southeast corner of the site in the anticipated upgradient groundwater flow direction (UW01, background), one overburden well in the central portion of the site (UW02), one overburden well in the northeast corner of the site in a vicinity immediately downgradient of the area of observed contamination (UW03), one overburden well along the southern boundary (UW04) and one overburden well in the northeast corner of the site (UW05) at a location in the anticipated downgradient flow direction of the groundwater.

Additional groundwater micro wells beyond those already scoped in this work plan will be installed if deemed necessary for this SASE by agreement between the Navy and all the regulatory oversight parties.

3.3.3.1 Groundwater Monitoring Well Screen Installation

The depth of the well screen installation will be determined in the field based on conditions that may include: depth to groundwater, vertical zones that are more or less permeable to water than others, soil types present, headspace screening results, visual evidence of contamination (and an absence of field

TABLE 3-3
SAMPLE CONTAINER, PRESERVATIVE, AND HOLDING TIME REQUIREMENTS
DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
SURFACE WARFARE OFFICERS SCHOOL
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

SAMPLE MEDIUM	ANALYSIS	SAMPLE CONTAINER	PRESERVATIVE	HOLDING TIME	USEPA/ NFESCDQO LEVEL ⁽¹⁾
Soils	TCL VOCs (SW 836-5035A, 8260B) and GRO	4-40 ml VOA vials	5 mls reagent grade water, freeze	14 Days (Analysis)	IV
	TCL SVOCs (SW846 8270)	8 oz wide mouth jar	Cool to 4oC	7 Days (Extraction)	IV
	TCL PCBs/Pesticides (SW846 8081, 8082)	8 oz wide mouth jar	Cool to 4oC	7 Days (Extraction)	IV
	TAL Metals (SW846, 6010B)	4 oz wide mouth jar	Cool to 4oC	Hg 28 Days, Others 6 months	IV
	DRO Method 8015B modified	8 oz wide mouth jar	Cool to 4oC	28 days	III
	Percent Moisture	2-oz glass jar	Cool to 4oC	14 days analysis	III
Groundwater	TCL VOCs (SW846, 8260B)	2 - 40 ml VOA vials	HCl to pH <2/Cool to 4°C	14 Days (Analysis)	IV
	TCL SVOCs (SW846-8270)	80 oz amber bottle	Cool to 4°C	7 Days (Extraction)	IV
	TCL PCBs/Pesticides (SW846, 8081 8082)	80 oz amber bottle	Cool to 4°C	7 Days (Extraction)	IV
	TAL Metals Dissolved Metals (SW846-6010B)	1 liter PE bottle	HN0 ₃ to pH <2	Hg 28 Days, Others, 6 months	IV
	DRO/GRO Method 8015B modified	1 liter PE bottle	HN0 ₃ to pH <2	Hg 28 Days, Others, 6 months	IV
	Specific Conductance (YSI 600XL [GW], Horiba U-22 [SW])	2 - 40 ml VOA vials	HCl to pH <2/Cool to 4°C	14 Days (Analysis)	
	pH (YSI 600XL [GW], Horiba U22 [SW])	Field Measurement	Not Applicable	Not Applicable	I
	Temperature (YSI 600XL[GW], Horiba U-22 [SW])	Field Measurement	Not Applicable	Not Applicable	I
	Dissolved Oxygen (YSI 600XL [GW]; Horiba U-22[SW])	Field Measurement	Not Applicable	Not Applicable	I
	Turbidity (LaMotte turbidity meter [GW], Horiba U-22 [SW])	Field Measurement	Not Applicable	Not Applicable	I
	Oxidation Reduction Potential (YSI 600XL [GW], Horiba-22[SW])	Field Measurement	Not Applicable	Not Applicable	I

(1) USEPA and Naval Facilities Engineering Service Center Data Quality Objectives for laboratory data deliverables (see text)

TABLE 3-4
FIELD QUALITY CONTROL SAMPLE SUMMARY
DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
SURFACE WARFARE OFFICERS SCHOOL
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

SAMPLE TYPE	MEDIA	ANALYSIS	FIELD SAMPLES ⁽¹⁾	FIELD DUPLICATES (1 PER 10 FIELD SAMPLES)	RINSATE BLANKS ⁽²⁾	SOURCE BLANKS (1 PER WATER SOURCE PER EVENT)	TRIP BLANKS (1 PER 10, 1 PER SHIPMENT)	TOTAL QUANTITY ⁽³⁾
Geologic/ Hydrogeologic Investigation	Soils	TCL VOCs	40	4	4	1	4	53
		TCL SVOCs	40	4	4	1	0	49
		Pesticides/PCBs	40	4	4	1	0	49
		TAL Metals	40	4	4	1	0	49
		GRO/DRO (8015B mod)	40	4	4	1	0	49
	Groundwater	TCL VOCs	5	1	1	0	1	8
		TCL SVOCs	5	1	1	0	0	7
		Pesticides/PCBs	5	1	1	0	0	7
		TAL Metals	5	1	1	0	0	7
		GRO/DRO (8015B mod.)	5	1	1	0	0	7

(1) Refer to Table 3-1 for number of field samples anticipated

(2) One rinsate blank per type of tool or sampling procedure used

(3) In order to accommodate laboratory quality control analyses (i.e , matrix spike, matrix spike duplicate, laboratory duplicate) the field crew will provide multiple aliquots of samples (as applicable) with a frequency of one per 20 samples of similar matrix

instrument response to headspace screening), the presence of multiple horizons of contaminants, and depth to bedrock.

Table 3-2 describes the location, the expected screened interval, and the purpose of each of the micro wells to be installed.

Each micro well will be installed using prepacked well screens in order to reduce damage to the newly constructed parking areas near the SWOS building. Each 5-foot prepacked well screen assembly is comprised of an inner flush threaded 0.010 inch slotted schedule 40 PVC, and an outer 65 mesh stainless steel screen, that supports a 20-40 (0.85 mm - 0.425 mm) silica sand filter pack.

The well screens will be installed in the saturated zones, if possible, across the interval that shows the highest level of contamination. However, if conditions warrant it (i.e., if contaminants detected by headspace screening indicate the presence of a light non-aqueous phase liquid [LNAPL]), screens may be placed across the water table to sample the LNAPL. Such changes to the work plan will be documented to the regulatory parties in Field Modifications Requests as described in Section 1.5 of this work plan.

Overburden aquifer wells will be installed according to the following protocol: clean silica sand of uniform grain size will be carefully placed under the well screen (six inches minimum thickness) to provide a firm footing and allow unrestricted flow under the screened interval. The same uniform sand mixture will be placed in the annular space between the pre-packed well screen and boring wall, to a minimum of 1 foot above the top of the screen. A bentonite pellet seal with a minimum thickness of 2 feet will then be installed immediately above the silica sand backfill. The bentonite pellet seal will be brought up to 4 feet below ground surface. A one-foot thick layer of clean silica sand (such as that used for the sand pack) will be added to serve as a drainage layer beneath the protective casing. This minimizes the possibility of water collecting and freezing in the annular space between the casing and the riser. The hole will be finished with a cement grout seal and a protective flush-mounted roadway box, where appropriate.

During the well installation process, the depths of all backfill materials will be continually monitored with a weighted tape. Wells will be completed at the ground surface using flush-mounted road boxes. Wells located within paved areas will be finished with concrete grout to match the existing grade of the surrounding paved surfaces.

Bentonite grout will be allowed to set for a minimum of one day prior to developing the well. Development will be conducted by bailing, or pumping and surging, to remove residual drill cuttings and fines from around the well screens.

The horizontal and vertical locations of the wells will be surveyed following the completion of well construction. The top of the PVC well riser will be marked for use as a permanent reference point. The survey operations are described in detail in Section 3.4 of this work plan. Well purge water will be containerized in accordance with Section 3.5 of this work plan.

3.3.4 Well Development

Wells will be developed by bailing and/or surging and pumping, as determined by the field geologist. Fine-grained material around the well screen will be drawn into the well and removed by agitating the well water with a foot valve and simultaneously pumping water from the well at a low discharge rate. A peristaltic pump outfitted with ASTM drinking water grade polyethylene tubing may also be used for removing the water from the well. To prevent cross contamination between the wells, the down hole equipment will be decontaminated between use in each well. The decontamination will use non-phosphate detergent and tap water, rinsed with tap water, rinsed with 2-propanol, and rinsed with deionized water. The polyethylene tubing will also be replaced between each well. Water produced during well development will be containerized in 55-gallon drums (DOT Specification 17E), as described in Section 3.5 of this work plan, and placed in a locked storage container until disposal.

Based on field conditions, should the use of the surge block and pumping technique be deemed inappropriate by the TtNUS field team, an alternative method will be used to develop the well. A suitable pumping device (e.g., submersible bladder pump or a Whale[®] pump) will instead be placed in the well and used for its development.

The volume of groundwater extracted from each monitoring well during development will be monitored for the following water quality parameters: pH, temperature, oxidation reduction potential (ORP), specific conductance, dissolved oxygen, and turbidity at 15 minute intervals using a water quality meter. Development will continue until pH, temperature, and specific conductance have all stabilized and turbidity is equal to or less than 10 nephelometric turbidity units (NTUs). The well will be considered stable when consecutive readings differ less than 10 percent. If the NTU criteria is not achievable, the parties will determine if a turbidity standard of plus or minus 10 percent of successive well volumes is appropriate on a case-by-case basis.

If a well is not completely developed after 4 hours, the field geologist will notify the TtNUS project manager for authorization to continue or to stop development.

3.3.5 Groundwater Sample Collection

Investigations of groundwater quality have not been previously conducted at this site. One round of groundwater sampling and analysis will be conducted during this investigation. Due to concerns regarding high turbidity effects on the collection of representative, accurate, and reproducible groundwater quality samples, a low stress (low-flow) sample collection procedure will be used for this task. Samples will be collected from each of the newly installed micro wells and will include applicable field QA/QC samples (blanks and duplicates).

Groundwater samples will be analyzed for full TCL organics, TAL metals (total and dissolved metals), and DRO/GRO analyses. Table 3-1 presents a summary of field samples to be collected. Section 4.0 of this work plan describes analytical methodologies and QC requirements.

Work elements for this task include:

- Noting, measuring and, if possible, sampling non-aqueous phase liquids (both LNAPL and DNAPL).
- Measuring water levels in newly installed wells prior to purging, in addition to wells located on the OFFTA site.
- Purging wells using the low stress (low-flow) methodology.
- Periodically measuring pH, temperature, specific conductance, dissolved oxygen, ORP, turbidity, water level, and pumping rate while water is being extracted from the well.
- Collecting samples from the micro wells using the USEPA low stress (low-flow) methodology.
- Documenting, packing, and shipping samples for analysis.

Procedure

For each well to be sampled, the low stress (low flow) sample collection procedures to be followed are summarized below. The USEPA Region I SOP for low flow sample collection (SOP GW-0001, 7/30/96, Revision 2) is presented in Appendix B. This SOP will be followed, as practical, during the collection of groundwater samples. If the EPA method is unsuccessful in the collection of a groundwater sample, standard bailing techniques will be used.

The following steps provide a guideline for the low flow groundwater sample collection:

1. The presence of floating product in the wells will be determined with the use of an immiscible liquid interface probe (or equivalent). The presence of product will be noted, and if appropriate, the thickness measured and sampled (see Section 3.3.5.1 if applicable). The depth to water in the well will be measured and recorded to the nearest 0.01 feet, minimizing immersion of the meter within the standing water column to avoid disturbance of colloidal particles.
2. The required length of tubing will be calculated and measured for attachment to the peristaltic pump tubing intake placed at the midpoint of the saturated screened interval. Note that the tubing will be measured to allow a minimum distance between the well head and the discharge point (field testing equipment), to minimize temperature changes in the groundwater discharged from the well. Teflon or teflon-lined tubing will be used and disposed of after sampling is complete at each well.
3. The tubing will be slowly and smoothly lowered to the required depth to minimize the amount of mixing in the well. The pump's discharge tubing will be fastened to the well casing (or PVC stick-up) to minimize movement.
4. The field testing equipment will be assembled, and placed as close as possible to the well head/discharge tubing. The discharge tubing will be connected to the pump head with a minimum length of pharmaceutical grade silicone tubing.
5. The peristaltic pump will be connected to the power supply (battery, generator or other power source) and the power supply turned on (without starting the pump).
6. The depth to water with the pump tubing in the well will be re-measured with the water level indicator or interface probe and compared with the initial reading; if the readings vary by more than 0.05 feet, field personnel will wait five minutes, re-measure the water, and begin pumping.
7. The pump will be started at a low speed setting until discharge occurs. The pump start time will be recorded, the flow rate measured (adjusted as necessary to within acceptable limits), and recorded using a graduated measuring device and stopwatch. (Note that during the initial period of pumping, an estimated 5 to 10 minutes, the depth to water in the well should be measured frequently (at an estimated frequency of approximately once per minute), to enable timely pump flow adjustments to attempt to minimize significant drawdown in the well).

8. During well purging, purge water discharged from the tubing will be collected in a flow-through cell. Water quality parameters for pH, temperature, specific conductance, ORP, and dissolved oxygen will be measured during purging using a YSI model 600 XL water quality meter (or equivalent) and recorded. Turbidity will be measured using a LaMotte 2020 (or equivalent) meter from a sample aliquot that is collected before it reaches the flow-through cell. The sample aliquot will be collected using an in-line T-fitting and ball valve or similar device.
9. Water quality parameters (pH, temperature, specific conductance, ORP, turbidity, and dissolved oxygen) and the depth to water in the well will be measured at three to five-minute intervals as purging occurs. The data and the associated time will be recorded on the low-flow sampling data sheet. Attempts will be made to maintain the drawdown in the well during pumping to 0.3 feet or less, by adjusting the pump flow rate. Drawdown for each well will vary depending on the recharge capacity of the well. If stabilization of field parameters does not occur utilizing the low stress (low flow) procedure, the field crew will consult with the project manager, who will make the determination as whether to collect the sample or not. It is most likely that the sample will be collected and the data from that sample will have to be qualified with the information as to which parameters did not stabilize.
10. Purging will continue until all of the parameters have stabilized. "Stabilization" will be considered achieved when three consecutive readings are within the following limits:
 - Turbidity (10% for values greater than 1 NTU, as practical).
 - DO (10%).
 - Specific conductance (3%).
 - Temperature (3%).
 - pH (± 0.1 unit).
 - ORP/Eh (± 10 millivolts)

Groundwater samples will be collected following the stabilization of the measured field parameters. The discharge tubing will be disconnected from the flow-through cell and the in-line device used to collect aliquots for separate turbidity measurements. Samples will be collected directly through the discharge tubing into appropriate sample bottles. The sample aliquot for VOC analysis shall be collected directly into pre-preserved 40-mL amber vials with minimal disturbance. The bottles should be filled completely with no headspace remaining in the bottle. VOC samples shall not be opened after collection. An extra vial shall be collected initially to check the pH of the sample. If the desired pH is not obtained, five drops of hydrochloric acid (HCl) shall be placed into new 40-mL vials and the sample will be recollected. The process is repeated until pH < 2 is achieved. The samples shall be recollected with the appropriate

amount of HCl. If effervescence is noted when the samples are collected, the samples shall be recollected without preservative and shipped to the laboratory as soon as possible. Samples will be preserved according to requirements described in Section 4.0. All non-disposable sampling equipment will be decontaminated prior to each use, as described in Section 3.5. All pertinent sampling data will be recorded on appropriate sample log sheets and in the site logbook. Any field deviations shall be recorded on a Field Modification Record.

If difficulties arise during low stress (low flow) sample collection procedures (i.e. minimum drawdown is not obtainable; it can't be documented that the well is yielding fresh water despite the drawdown; or water chemistry readings do not show a stabilization pattern), affected wells may be sampled using standard bailing techniques. This change will constitute a field modification request as described in Section 1.5 of this work plan.

Appropriate chain-of-custody procedures will be followed (see Section 4.3.2) and samples will be labeled, packaged, and shipped according to TtNUS SOP No. SA-6.1.

3.3.5.1 Non-Aqueous Phase Liquids (NAPL) Sampling

If light or dense non-aqueous phase liquids (LNAPL or DNAPL) are determined to be present in the micro wells, samples are to be collected prior to well purging, to avoid disruption of the NAPL layer. Two methods will be available for the collection of the free phase samples and will include:

1. Sampling by slowly lowering a "trap door" bailer or other vertical trap to the target depth measured with the interface probe, or
2. Sampling with a peristaltic pump by carefully lowering the teflon collection tube to the target depth measured with the interface probe.

The method selected will be based on the depth and apparent thickness of the non-aqueous phase liquid. Deeper (greater than 15 to 20 feet) and "thinner" layer samples (less than 0.1 foot) can make accurately placing the teflon collecting tubing for the peristaltic pump difficult. If necessary, product mixed with water can be collected and allowed to separate within a sample container. Once the NAPL layer has separated from the water portion of the sample, it may be extracted using a peristaltic pump under controlled conditions and containerized for analysis as required by the analytical laboratory.

3.4 TASK 3: LAND SURVEY

Following the investigative work, a survey will be performed by a surveyor registered in the State of Rhode Island to identify horizontal locations of sample points, and other significant features identified during the investigation. The survey will be performed by a subcontractor supervised by TtNUS working under the site specific Health and Safety Plan.

The base map presented in this work plan (Figure 3-1) will be used; however, locations of existing buildings and study area boundaries will be confirmed by survey.

The survey will be conducted to establish relative locations of sample points. Survey control will be maintained by tying into either the State of Rhode Island or United States Geological Survey (USGS) grid systems. Elevations will be referenced to a USGS benchmark and the Navy mean low water level. Horizontal and vertical measurements will be made relative to on-site control points.

All surveyed features will be horizontally located to within ± 0.1 foot. Tops of PVC well risers and will be located to plus or minus 0.01 foot vertically.

It is expected that each of the soil boring and micro well locations and elevations will require location surveying.

Surveyed points will be mapped with AutoCAD LT 2000i or a compatible system. The survey subcontractor will provide hard-copy prints and disk versions of the survey information for each survey operation. Survey points for each task will be set on different "layers" of the AutoCAD data such that printouts of sample collection points can be made specific to each task.

3.5 INVESTIGATION-DERIVED WASTE (IDW)

Waste materials that will be generated during the field investigation may include drill cuttings, well purge and development water, decontamination fluids, disposable sampling equipment, and used personal protective equipment (PPE).

TtNUS will be responsible for removing and properly disposing of all investigative waste materials following completion of the field investigation program. This waste disposal program will be conducted, as appropriate, following each of the tasks described in the previous sections of this work plan. In this manner, large quantities of wastes will not be stockpiled for disposal at the end of the investigation program.

Containers of IDW will be labeled as to their point of origin and date collected and placed in a locked storage container until disposal. Samples of these materials will be labeled with the information on the containers. Containers of IDW that are found to be hazardous will be characterized and disposed of within 90 days.

3.5.1 Solid Wastes

Personal protective equipment (gloves, tyvek coveralls, and disposable boots) will be decontaminated, double bagged, and disposed of in an off-site industrial dumpster.

3.5.2 Soil Wastes

Excess drill cuttings, discarded sample material, and other soil wastes will be containerized. Soils from different areas will not be mixed.

Laboratory analysis of samples collected during the investigation program will be used to further characterize the waste materials, as required by state and federal disposal requirements. Additional samples for other parameters will also be required. Typical disposal parameters are listed below.

- TCLP Metals
- TCLP Volatile Organic Compounds
- TCLP PCB/Pesticide Compounds
- Flash Point, Reactivity, Corrosivity
- Free Liquid

Analysis of representative samples of waste materials for disposal parameters will be the responsibility of an outside disposal subcontractor. All soil wastes will be shipped off site by this same subcontractor.

3.5.3 Liquid Wastes

Decontamination fluids and well purge and development water will be initially contained in 55-gallon drums. This material will be combined at the conclusion of the project and shipped off site for disposal in accordance with RIDEM, USEPA, and DOT Regulations.

3.6 DECONTAMINATION PROCEDURES

Equipment decontamination procedures are described in TtNUS SOP SA-7.1 and have been summarized below:

Monitoring Equipment

To the extent possible, all monitoring equipment will be wrapped and sealed in plastic with only the controls, readouts, and intake and exhaust ports open to the atmosphere. If decontamination of monitoring equipment is required, the following procedure will be utilized:

- Remove plastic covering.
- Remove gross contamination with potable water.
- Scrub with potable water/liquinox.
- Rinse lightly with potable water.
- Wipe dry immediately with disposable towels.

Drilling, Excavation, and Other Heavy Equipment

The DPT rigs and down hole equipment will be decontaminated following their arrival on site, prior to beginning work at each location, and at the completion of the drilling programs.

Rig decontamination will be performed at a temporary, centrally located decontamination pad constructed specifically for this purpose. The decontamination pad will be large enough to capture all wash water and channel it into a sump. The fluids in the sump will be containerized after each use.

Sampling Equipment

All non-disposable sampling equipment that comes in contact with the sample medium will be decontaminated to prevent cross contamination between sampling points. This includes equipment such as drill rods, soil sampling spatulas, and bowls, etc. The following decontamination sequence will be employed:

- Remove gross contamination by scrubbing with potable water.
- Scrub with potable water/liquinox.
- Rinse with potable water.
- Rinse with deionized water.

- Rinse with 2-propanol.
- Rinse with hexane
- Rinse with deionized water.
- Air dry (to extent possible).
- Wrap with aluminum foil, dull side toward equipment.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

This section provides technical guidelines and procedures for conducting the field work. This document references the TiNUS Standard Operating Procedures (SOPs) for specific protocols for procedures discussed in Section 3.0.

Pertinent SOPs are included in this work plan as Appendix B. These SOPs include, but are not limited to:

<u>SOP</u>	<u>DESCRIPTION</u>
GH-1.3	Soil Sampling
GH-1.5	Borehole and Sample Logging
GH-2.8	Groundwater Monitoring Well Installation
GH-2.5	Groundwater Contour Maps and Flow Determinations
SA-1.1	Groundwater Sample Acquisition and Onsite Water Quality Testing
SA-2.5	Direct Push Technology
SA-6.1	Non-Radiological Sample Handling
SA-6.3	Field Documentation
ME-15	Photovac MicroFID Handheld Flame Ionization Detector

In addition, the following policies and guidance are provided for reference:

RIDEM (1996) Required Monitoring Well Construction Standards and Abandonment Procedures
 EPA-GW-0001 Low Flow Groundwater Sampling
 Total Volatile Organic Compounds Jar Headspace Screening

Data quality objectives for the SWOS site SASE are developed in Section 2.6 of this work plan. The objectives of the sampling program are to provide sufficient data to identify and characterize possible contaminants present in soils and groundwater at the site. This characterization and the data developed from the sampling program must be of adequate quality to support a baseline risk assessment, and to provide waste characterization data for making remedial decisions. To accomplish these objectives, samples will be collected for laboratory analyses as described in Section 3 of this work plan.

4.1 PARCC PARAMETERS

Achieving these objectives requires that the data collected from the field conform to an appropriate level of quality. The quality of a data set is measured by certain characteristics of the data, namely the precision and accuracy, representativeness, completeness, and comparability (PARCC) parameters. Some of the parameters are expressed quantitatively, while others are expressed qualitatively. The PARCC goals for a particular project are determined by the intended use of the data, usually referred to as DQOs. DQOs are developed in Section 2.6 of this work plan; the PARCC parameters are discussed in the following subsections.

4.1.1 Precision and Accuracy

Field and laboratory precision and accuracy performance can affect the attainment of project objectives, particularly when compliance with established criteria is based on laboratory analysis of environmental samples.

Analytical precision and accuracy will be evaluated upon receipt of the analytical (field screened and laboratory) data. Analytical precision will be measured as the relative percent difference from duplicate measurements and relative standard deviation from three or more replicates. Analytical accuracy measures the bias as the percent recovery from matrix spike and matrix spike duplicate samples.

Field sampling precision and accuracy are not easily measured. Field contamination, sample preservation, and sample handling will affect precision and accuracy. By following the appropriate TtNUS SOP, precision and accuracy errors associated with field activities can be minimized. Field duplicates and blanks (field, trip, and rinsate) will be used to estimate field sampling precision and accuracy for soil samples submitted for laboratory analysis.

Field duplicate and field quality control blank analyses results will be used to review the laboratory-analyzed results and determine the usability of the data with respect to its intended use. In general, results that are rejected by the data review process will be disqualified from application to the intended use. Qualified data will be used to the greatest extent practicable.

4.1.2 Representativeness

Representativeness describes the degree to which analytical data accurately and precisely define the population being measured. Several elements of the sampling and sample handling process must be controlled to maximize the representativeness of the analytical data (appropriate number of samples

collected, physical state of the samples, site-specific factors, sampling equipment, containers, sample preservation and storage, holding times, sample identity and chain of custody will be defined to ensure that the samples analyzed represent the population being measured). The sampling program is designed to provide analytical data that is representative of the existing contaminant levels.

Every effort will be made to collect soil samples that represent the soil under investigation. For the headspace screening procedure the type and concentration of the contaminants in the samples screened on site depends on the type of contaminants present in the soil samples and their concentration. The volatile contaminants in the headspace represent the volatile contaminants in the soil in the container. The sample with the highest concentration of volatile contaminants in the soil will deliver the highest concentration of volatile contaminants to the headspace container.

Headspace screening data (FID/PID) will not be used to make determinations of true nature or extent of contamination. The screening data will be used to aid in determining micro well screen installation selection. The laboratory samples alone will be used to determine nature and extent of contamination as part of the SASE.

Representativeness of data is also affected by sampling techniques. Sampling techniques are described in Section 3.0 and in the TtNUS SOP included in Appendix B.

4.1.3 Completeness

Completeness describes the amount of data generated that meets the objectives for precision, accuracy, and representativeness versus the amount of data expected to be obtained. For relatively clean, homogeneous matrices, 100 percent completeness is expected. However, as matrix complexity and heterogeneity increase, completeness may decrease. Where analysis is precluded or where data quality objectives are compromised, effects on the overall investigation must be considered. Whether or not any particular sample is critical to the investigation will be evaluated in terms of the sample location, the parameter in question, the intended data use, and the risk associated with the error.

The sampling and analysis program for the site is sufficiently broad in scope to prevent a single data point or parameter from jeopardizing attainment of the monitoring objectives. Each medium is critical to the assessment of contaminant migration. Consequently, there exists some critical data requirement below which the objectives of the monitoring program will be compromised.

Critical data points may not be evaluated until all the analytical results are evaluated. Additionally, several sampling points, in aggregate, may be considered to be critical either by location or by analysis.

A subsequent sampling event may be necessary if it becomes apparent that the data for a specific medium are of insufficient quality, either with respect to the number of samples or an individual analysis.

For the purposes of this effort, a data point will be determined to contribute to the completeness of the data set if the information provided is meaningful, useful, and contributes to the project objectives.

4.1.4 Comparability

One of the objectives of the sampling effort is to provide analytical data that is characterized by a level of quality that is comparable between sampling points. By specifying the use of standard analytical procedures (as well as standardizing field sampling procedures by following TtNUS and other SOPs), the potential for variables to affect the final data quality will be effectively minimized. Analytical methods for this work are shown in Table 3-3, and SOPs appear in Appendix B.

4.2 QUALITY CONTROL SAMPLES

QC samples to be collected during the sampling effort are identified below, and include field duplicates, rinsate blanks, source blanks, trip blanks, and matrix spike/matrix spike duplicates. Each type of field quality control sample defined below will undergo the same preservation, holding times, etc., as the field samples. Table 3-4 presents a summary of these QC samples to be collected during this field investigation.

4.2.1 Field Duplicates

Field duplicates will be submitted at the rate of one for every 10 samples per matrix, or at a rate greater than one per 10 samples if less than 10 are shipped to the laboratory on any given day. Field personnel will note on the sample summary form and in the logbook which samples are field duplicates. Duplicate samples will be shipped blind to the laboratories, and shipping paperwork will be completed accordingly.

Field personnel will note in the remarks block on the chain-of-custody form which of the samples is to be used for internal laboratory matrix spike/matrix spike duplicate analysis. Field duplicates and multiple sample aliquots are collected by mixing a double portion of the required volume of sample and dividing it into two sample containers. Aliquots for VOC analysis are always removed prior to homogenization. Field duplicates provide precision information regarding homogeneity, handling, shipping, storing, preparation, and analysis.

4.2.2 Rinsate Blanks

Rinsate blanks are obtained under representative field conditions by running analyte-free deionized water through sample collection equipment after decontamination, immediately before sampling and placing it in the appropriate sample containers for analysis. These samples are used to assess the effectiveness of decontamination procedures. Rinsate blanks will be prepared at the rate of one per type of tool or sampling procedure used, and will be analyzed for the same parameters as the related samples. All rinsate samples will be sent to a laboratory for analysis.

4.2.3 Source Blanks

Source blanks will consist of the source water used in decontamination (includes analyte-free deionized water, potable water from each source, and other waters used in decontamination operations). Source blanks will be prepared at the rate of one per source of water per sampling event.

4.2.4 Trip Blanks

Trip blanks consist of aqueous VOC samples prepared by the laboratories and are shipped to the field sampling team along with the containers to be used for sample collection. One VOC trip blank sample will accompany sample containers into the field, through the sampling process, and will be sent with each shipment of VOC samples to the laboratories. If more than ten VOC samples are in one shipment, one trip blank sample will be provided for each ten field samples. If less than ten VOC samples are in one shipment, one trip blank will be provided. If there are multiple sampling crews out at one time, trip blanks will accompany each sampling team. If the samples are "pooled" in a single cooler for shipment, then the trip blanks accompanying each respective sampling team will be submitted for VOC analysis.

4.2.5 Matrix Spike/Matrix Spike Duplicates

A matrix spike sample will be identified by field teams at a frequency of one in 20 field samples collected. Samples for matrix spike analyses are collected in triplicate volume, such that there are three containers for each analyte group. One aliquot is analyzed as a field sample in a manner consistent with the other field samples. The second aliquot is spiked and analyzed to determine spike recoveries. The third is spiked also and analyzed as a duplicate to the second aliquot.

4.3 PROJECT ACTION LIMITS AND METHOD DETECTION LIMITS

For the SASE at the SWOS site, a complete list of target contaminants has not yet been identified. Existing data indicate TPHs and lead are present on site, but extensive sample analysis has not been conducted on the SWOS site to indicate the full nature of the contamination. Therefore, the analyte groups and methods for analysis identified in Section 3 of this work plan have been selected for the SASE data collection effort. These methods provide the appropriate range of analytes identified by the US EPA on the TCL and TAL (metals) for CERCLA, which is the lead regulatory driver for the NAVSTA Newport Installation Restoration Program, under which this study is being conducted.

Project action limits are typically selected from available regulatory and risk based target concentrations, also referred to as benchmarks or screening criteria. The screening criteria for this project will include, but may not necessarily be limited to regulatory criteria including maximum contaminant levels (MCLs) for groundwater, RIDEM direct exposure criteria for soil and other human risk based criteria such as Region IX Preliminary Remediation Goals.

Method detection levels (MDLs) and quantitation limits (QLs) will be provided by the proposed subcontract laboratory. These MDLs, as well as the project action limits, are presented on Tables 4-1A through 4-2D. Project action limits and MDLs are presented separately for soil (Tables 4-1A through 4-1D) and groundwater (Tables 4-2A through 4-2D). Action limits for soil were selected from the lowest criteria appropriate for human health risk as described within the table references. Action limits for groundwater were limited to human risk screening criteria for water supply (EPA Region IX PRGs for tap water, and Rhode Island GB groundwater objectives), since the site is in an area classified as GB, and groundwater flow direction at the site is not yet determined.

The MDLs are provided by the laboratory as what can be quantified with the cited method on the types of media expected. Many times, actual sample conditions, particularly in soil samples, will dictate the actual quantitation limit, which might be higher (or lower) than those stated. However, when the analytical laboratory identifies contaminants below their quantitation limit, they will report that detection as an approximate concentration. For this reason, many results are reported below the quantitation limits.

Because the analytical laboratory has not yet been selected and can not provide MDLs for inorganic analysis of soil samples prior to the press date of this work plan, the instrument detection limits provided to TtNUS by another program laboratory, Katahdin Analytical, are provided as an example of what can be expected to be achieved through the cited method analysis.

The project action limits are selected from risk-based and regulatory screening criteria as targets for the analytical laboratories and for the investigation. However, these are screening criteria, and some are extremely low concentrations, and impossible to achieve without very specialized analytical work. It is expected that some laboratory MDLs will be above these risk criteria for some contaminants, just as it is predicted that some of the samples will not provide quantitation limits within the levels expected by the laboratory. Actual detection limits that fall above the targets will have to be considered in the data evaluation and risk assessment processes.

4.4 SAMPLE DESIGNATION AND CUSTODY

Samples collected will be tracked by sample identification number and date and time of sample collection. The sample number will be the basis for maintaining chain of custody. These procedures are described below.

4.4.1 Sample Numbering

Samples will be labeled as soon as they are collected. Sample numbers will reflect the source, medium, and location. An alpha numeric numbering system will be used to describe this information. This system is detailed below:

AAAA - A - AANN -NNNN - NN
(Site Identifier) - (Medium) - (Sample Location) - (Depth)- (Round)

The site identifier for the SWOS site is SWOS. "Medium" indicates solid (S) or aqueous (A). Sample locations will be noted as UW for groundwater samples from micro wells and SB for soil boring samples. The addition of the sampling round number is only applicable to groundwater samples.

For example, a soil boring sample collected from 2-4 feet below ground surface from SB03 will be identified as SWOS-S-SB03-0204. The first groundwater sample (Round 1) collected from the micro well will be identified as SWOS-A-UW04-01.

Blind duplicate samples will be designated such that the location designation will be replaced with a chronological number:

Duplicates: SWOS-S-SB-DUP##

TABLE 4-1A
 SOIL- VOLATILE ORGANIC TARGET ANALYTES, METHOD 8260B
 DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
 SURFACE WARFARE OFFICERS SCHOOL
 NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/kg)	Source	Project Quantitation Limit (µg/kg)	Achievable Laboratory Limits	
					MDLs (µg/kg)	QLs (µg/kg)
Dichlorodifluoromethane	75-71-8	310000	HH	10	2 253	10
Chloromethane	74-87-3	2600	HH	10	2.577	10
Bromomethane	74-83-9	800	HH	10	7 247	10
Vinyl Chloride	75-01-4	750	HH	10	2.750	10
Chloroethane	75-00-3	6500	HH	10	1.450	10
Methylene Chloride	75-09-2	21,000	HH	10	34 539	10
Acetone	67-64-1	6000000	HH	10	32 655	10
Methyl Acetate	79-20-9	92000000	HH	10		10
Carbon Disulfide	75-15-0	720000	HH	10	2.103	10
Trichlorofluoromethane	75-69-4	2000000	HH	10	2 012	10
1,1-Dichloroethene	75-35-4	9,500	RIDEM	10	2 516	10
1,1,2-Trichloro-1,2,2-trifluoro-ethane	76-13-1	5600000	HH	10		10
1,1- Dichloroethane	75-34-3	1,700,000	HH	10	2 061	10
Methyl tert-Butyl Ether	1634-04-4	160,000	HH	10	1 895	10
cis-1,2- Dichloroethene	156-59-2	150,000	HH	10	1 886	10
trans-1,2- Dichloroethene	156-60-5	230,000	HH	10	1 570	10
Chloroform	67-66-3	12,000	HH	10	1.689	10
1,2- Dichloroethane	107-06-2	600	TV	10	1 159	10
2-Butanone	78-93-3	10,000,000	RIDEM	10	1 972	10
1,1,1-Trichloroethane	71-55-6	1,200,000	HH	10	1 954	10
Bromochloromethane	74-97-5	2400	HH	10	1 173	10
Cyclohexane	110-82-7	140000	HH	10		10
Carbon Tetrachloride	56-23-5	44000	RIDEM	10	2 336	10
Bromodichloromethane	75-27-4	92000	RIDEM	10	1 741	10
Methylcyclohexane	108-87-2	8700000	HH	10		10
1,2-Dichloropropane	78-87-5	84,000	RIDEM	10	1 116	10
Cis-1,3- Dichloropropene	10061-01-5	NA		10	1 085	10
Trichloroethene	79-01-6	110	HH	10	1 813	10
Dibromochloromethane	124-48-1	2600	HH	10		10
1,1,2- Trichloroethane	79-00-5	1600	HH	10	1 385	10
Benzene	71-43-2	1300	HH	10	1 402	10
Trans-1,3-Dichloropropene	10061-02-6	NA		10	0 951	10
Isopropylbenzene	98-82-8	20,000,000	HH	10	1.901	10
Bromoform	75-25-2	220000	HH	10	1 246	10
4-Methyl-2-Pentanone	108-10-1	2900000	HH	10	2 603	10
2-Hexanone	591-78-6	NA		10	1 535	10
Tetrachlorethene	127-18-4	3400	HH	10	1 645	10
1,1,2,2- Tetrachlorethane	79-34-5	930	HH	10	1 271	10
Ethylene Dibromide	106-93-4	NA		10		10
Toluene	108-88-3	520,000	HH	10	1.447	10
1,2-Dibromoethane	106-93-4	NA		10		10
Chlorobenzene	108-90-7	5,300,000	HH	10	1 463	10

TABLE 4-1A (cont.)
 SOIL- VOLATILE ORGANIC TARGET ANALYTES, METHOD 8260B
 DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
 SURFACE WARFARE OFFICERS SCHOOL
 NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND
 PAGE 2 OF 2

Analytes	CAS Number	Project Action Limit (µg/kg)	Source	Project Quantitation Limit (µg/kg)	Achievable Laboratory Limits	
					MDLs (µg/kg)	QLs (µg/kg)
Ethylbenzene	100-41-4	20,00	HH	10	1 718	10
Styrene	100-42-5	190,000	RIDEM	10	3 058	10
Total Xylenes	1330-20-7	420,000	HH	10	3 312	10
1,3-Dichlorobenzene	541-73-1	63000	HH	10	1 144	10
1,4- Dichlorobenzene	106-46-7	7900	HH	10	0 953	10
1,2- Dichlorobenzene	95-50-1	370000	HH	10	1 303	10
1,2-Dibromo-3-chloropropane	96-12-8	NA		10	2 327	10
1,2,4-Trichlorobenzene	120-82-1	3,000,000	HH	10	1 590	10

Sources in preferential order

HH - EPA Region IX PRGs for industrial use soils

RIDEM – Rhode Island Direct Exposure Criteria for Industrial Soils

TABLE 4-1B
SOIL - SEMIVOLATILE ORGANIC TARGET ANALYTES, METHOD 8270
DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/kg)	Source	Project Quantitation Limit (µg/kg)	Achievable Laboratory Limits	
					MDLs (µg/kg)	QLs (µg/kg)
Benzaldehyde	100-52-7	62,000,000	HH	330		330
Phenol	108-95-2	100,000,000	HH	330	269.99	330
Bis-(2-Chloroethyl) ether	111-44-4	5,200	RIDEM	330	329.45	330
2-Chlorophenol	95-57-8	10,000,000	RIDEM	330	301.77	330
2-Methylphenol	95-48-7	31,000,000	HH	330	273.00	330
2,2-oxybis(1-Chloropropane)	108-60-1	8,100	HH	330		330
Acetophenone	98-86-2	1,600	HH	330	209.31	330
4-Methylphenol	106-44-5	3,100,000	HH	330	343.29	330
N-Nitroso-di-n propylamine	621-64-7	250	HH	330	332.86	330
Hexachloroethane	67-72-1	410,000	HH	330	293.11	330
Nitrobenzene	98-95-3	100,000	HH	330	290.46	330
Isophorone	78-59-1	1,800,000	HH	330	275.09	330
2-Nitrophenol	88-75-5	NA		330	270.99	330
2,4-Dimethylphenol	105-67-9	1,000,000	RIDEM	330	341.77	330
Bis(2-Chloroethoxy) methane	111-91-1	NA		330	257.75	330
2,4-Dichlorophenol	120-83-2	6,100,000	HH	330	343.44	330
Naphthalene	91-20-3	NA		330	278.49	330
4-Chloroaniline	106-47-8	8,200,000	HH	330	443.38	330
Hexachlorobutadiene	87-68-3	22,000	HH	330	354.75	330
Caprolactam	105-60-2	100,000,000	HH	330		330
4-Chloro-3-methylphenol	59-50-7	NA		330		330
2-Methylnaphthalene	91-57-6	10,000,000	RIDEM	330	226.31	330
Hexachlorocyclopentadiene	77-47-4	3,700,000	HH	330	292.47	330
2,4,6-Trichlorophenol	88-06-2	62,000	HH	330	351.87	330
2,4,5-Trichlorophenol	95-95-4	62,000	HH	830	335.90	830
1,1'-Biphenyl	92-52-4	NA	HH	330	210.64	330
2-Chloronaphthalene	91-58-7	23,000,000	HH	330	232.02	330
2-Nitroaniline	88-74-4	18,000	HH	830	288.33	830
Dimethylphthalate	131-11-3	100,000,000	HH	330	181.58	330
2,6-Dinitrotoluene	606-20-2	620,000	HH	330	275.45	330
Acenaphthylene	208-96-8	10,000,000	RIDEM	330	250.36	330
3-Nitroaniline	99-09-2	NA		830	180.92	830
Acenaphthene	83-32-9	10,000,000	RIDEM	330	246.89	330
2,4-Dinitrophenol	51-28-5	1,200,000	HH	830	120.32	830
4-Nitrophenol	100-02-7	NA		830	227.26	830
Dibenzofuran	132-64-9	3,100,000	HH	330	381.19	330
2,4-Dinitrotoluene	121-14-2	8,400	RIDEM	330	207.95	330
Diethylphthalate	84-66-2	100,000,000	RIDEM	330	205.67	330
Fluorene	86-73-7	10,000,000	HH	330	240.71	330
4-Chlorophenyl-phenyl ether	7005-72-3	NA		330	176.01	330
4-Nitroaniline	100-01-6	NA		830	349.43	830
4,6-Dinitro-2-methylphenol	534-52-1	NA		830	179.73	830

TABLE 4-1B (cont.)
 SOIL- SEMIVOLATILE ORGANIC TARGET ANALYTES, METHOD 8270
 DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
 SURFACE WARFARE OFFICERS SCHOOL
 NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND
 PAGE 2 OF 2

Analytes	CAS Number	Project Action Limit (µg/kg)	Source	Project Quantitation Limit (µg/kg)	Achievable Laboratory Limits	
					MDLs (µg/kg)	QLs (µg/kg)
N-Nitroso diphenylamine	86-30-6	35,000	HH	330		330
4-Bromophenyl-phenylether	101-55-3	NA		330	260 97	330
Hexachlorobenzene	118-74-1	3,600	RIDEM	330	195.58	330
Atrazine	1912-24-9	7800	HH	330		330
Pentachlorophenol	87-86-5	9,000	HH	830	257.59	830
Phenanthrene	85-01-8	10,000,000	RIDEM	330	228 61	330
Anthracene	120-12-7	10,000,000	RIDEM	330	292 67	330
Carbazole	86-74-8	86,000	HH	330	203 67	330
Di-n-butylphthalate	84-74-2	NA		330	233.38	330
Fluoranthene	206-44-0	10,000,000	RIDEM	330	244 91	330
Pyrene	129-00-0	10,000,000	RIDEM	330	231 84	330
Butylbenzylphthalate	85-68-7	100,000,000	HH	330	273 04	330
3,3'-Dichlorobenzidine	91-94-1	5500	HH	330	238 49	330
Benzo (a) anthracene	56-55-3	2,100	HH	330	213 58	330
Chrysene	218-01-9	210,000	HH	330	230.51	330
bis(2-Ethylhexyl) phthalate	117-81-7	120,000	HH	330	361 01	330
Di-n-octylphthalate	117-84-0	25,000,000	HH	330	386 67	330
Benzo (b) fluoroanthene	205-99-2	2,100	HH	330	184 87	330
Benzo (k) fluoroanthene	207-08-9	21,000	HH	330	246 01	330
Benzo (a) pyrene	50-32-8	210	HH	330	244.82	330
Indeno (1,2,3-cd)-pyrene	193-39-5	2,100	HH	330	328.80	330
Dibenzo (a,h)-anthracene	53-70-3	210	HH	330	259 79	330
Benzo (g,h,i) perylene	191-24-2	10,000,000	RIDEM	330	199 38	330

Sources (criteria in preferential order)

HH - USEPA Region IX PRGs for industrial soils

RIDEM - RIDEM Direct Exposure Criteria for industrial soils

TABLE 4-1C
SOIL – PESTICIDES/PCB TARGET ANALYTES
DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/kg)	Source	Project Quantitation Limit (µg/kg)	Achievable Laboratory Limits	
					MDLs	QLs (µg/kg)
alpha-BHC	319-84-6	NA		1.7	0.495	1.7
beta-BHC	319-85-7			1.7	1.266	1.7
delta-BHC	319-86-8			1.7	0.473	1.7
gamma-BHC	58-89-9			1.7	0.438	1.7
Heptachlor	76-44-8	380	HH	1.7	0.536	1.7
Aldrin	309-00-2	100	HH	1.7	0.538	1.7
Heptachlor epoxide	1024-57-3	190	HH	1.7	0.507	1.7
Endosulfan I	959-98-8	NA		1.7	0.536	1.7
Endosulfan II	33213-65-9	NA		3.3	1.740	3.3
Endosulfan sulfate	1031-07-8	NA		3.3	1.056	3.3
Dieldrin	60-57-1	400	HH	3.3	0.702	3.3
Endrin	72-20-8	180,000	HH	3.3	0.837	3.3
Endrin ketone	53494-70-5	NA		3.3	0.930	3.3
Endrin aldehyde	7421-93-4	NA		3.3	0.954	3.3
4,4'-DDE	72-55-9	7,000	HH	3.3	0.802	3.3
4,4'-DDD	72-54-8	10,000	HH	3.3	1.740	3.3
4,4'-DDT	50-29-3	7,000	HH	3.3	1.593	3.3
Methoxychlor	72-43-5	3,100,000	HH	17	4.576	17
alpha-Chlordane	5103-71-9	NA		1.7	0.369	1.7
gamma-Chlordane	5103-74-2	NA		1.7	0.376	1.7
Toxaphene	8001-35-2	1,600	HH	170	25.869	170
Aroclor-1016	12674-11-2	740	HH	33	179.49	33
Aroclor-1221	11104-28-2			67		67
Aroclor-1232	11141-16-5			33		33
Aroclor-1242	53469-21-9			33	179.49	33
Aroclor-1248	12672-29-6			33	14.29	33
Aroclor-1254	11097-69-1			33		33
Aroclor-1260	11096-82-5			33	6.68	33

Source:

HH – Region IX PRGs for industrial use soils

NA – Not Available

TABLE 4-1D
 SOIL- INORGANIC TARGET ANALYTES METHOD 6010B AND 6020
 DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
 SURFACE WARFARE OFFICERS SCHOOL
 NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (mg/kg)	Source	Project Quantitation Limit (mg/kg)	Achievable Laboratory Limits	
					MDLs	QLs (mg/kg)
Aluminum	7429-90-5	100,000	HH	0.82	0.82	30
Antimony	7440-36-0	410	HH	0.13	0.13	0.8
Arsenic	7440-38-2	7.0	RIDEM	0.11*	0.11*	0.5
Barium	7440-39-3	10,000	HH	0.012	0.012	0.5
Beryllium	7440-41-7	1900	HH	0.023	0.023	1.0
Cadmium	7440-43-9	450	HH	0.028	0.028	5.0
Calcium	7440-70-2	NA		0.71	0.71	1.5
Chromium	7440-47-3	450	HH	0.057	0.057	3.0
Cobalt	7440-48-4	1900	HH	0.044	0.044	2.5
Copper	7440-50-8	41,000	HH	0.091	0.091	1.0
Iron	7439-89-6	100,000	HH	0.93	0.93	10
Lead	7439-92-1	500	RIDEM	0.091	0.091	0.5
Magnesium	7439-95-4	NA		0.41	0.41	5.0
Manganese	7439-96-5	10,000	RIDEM	0.015	0.015	0.5
Mercury	7439-97-6	62		0.007	0.007	0.05
Nickel	7440-02-0	10,000	HH	0.065	0.065	4.0
Potassium	7440-09-7	NA		1.51	1.51	100
Selenium	7782-49-2	5100	HH	0.21	0.21	1.0
Silver	7440-22-4	5100	HH	0.057	0.057	1.5
Sodium	7440-23-5	NA		18.4	18.4	100
Thallium	7440-28-0	67	HH	0.012*	0.012*	1.5
Vanadium	7440-62-2	7200	HH	0.036	0.036	2.5
Zinc	7440-66-6	10,000	RIDEM	0.024	0.024	2.5

Notes

MDL for mercury from Alpha Analytical Laboratory, others are Instrument Detection Limits from Katahdin Analytical, see text.

* Arsenic and thallium to be analyzed by Method 6020, others by Method 6010B

NA Not Available

Sources (in preferential order)

HH - Region IX Industrial Soil Screening Criteria

RIDEM – RIDEM Direct Exposure Criteria for Industrial Soils

TABLE 4-2A
GROUNDWATER – VOLATILE ORGANIC TARGET ANALYTES, METHOD 8260B
DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/L) ⁽¹⁾	Project Quantitation Limit (µg/L)	Achievable Laboratory Limits	
				MDLs ⁽³⁾ (µg/L)	QLs (µg/L)
Dichlorodifluoromethane	75-71-8	390	10	0.220	10
Chloromethane	74-87-3	1.5	10	0.263	10
Bromomethane	74-83-9	8.7	10	0.180	10
Vinyl Chloride	75-01-4	0.02	10	0.258	10
Chloroethane	75-00-3	4.6	10	0.670	10
Methylene Chloride	75-09-2	4.3	10	0.306	10
Acetone	67-64-1	610	10	0.523	10
Methyl Acetate	79-20-9	6100	10		10
Carbon Disulfide	75-15-0	1000	10	0.259	10
Trichlorofluoromethane	75-69-4	1300	10	0.324	10
1,1-Dichloroethene	75-35-4	340	10	0.409	10
1,1,2-Trichloro-1,2,2-trifluoro-ethane	76-13-1	59000	10		10
1,1-Dichloroethane	75-34-3	810	10	2.258	10
Methyl tert-Butyl Ether	1634-04-4	13	10	0.184	10
cis-1,2-Dichloroethene	156-59-2	61	10	0.146	10
trans-1,2-Dichloroethene	156-60-5	120	10	0.238	10
Chloroform	67-66-3	6.2	10	0.185	10
1,2-Dichloroethane	107-06-2	0.12	10	0.218	10
2-Butanone	78-93-3	1900	10	0.256	10
1,1,1-Trichloroethane	71-55-6	3200	10	0.396	10
Cyclohexane	110-82-7	35000	10		10
Carbon Tetrachloride	56-23-5	0.17	10	0.309	10
Bromodichloromethane	75-27-4	0.18	10	0.220	10
Methylcyclohexane	108-87-2	5200	10		10
1,2-Dichloropropane	78-87-5	0.16	10	0.236	10
cis-1,3-Dichloropropene	10061-01-5	NA	10	0.147	10
Trichloroethene	79-01-6	0.028	10	0.265	10
Dibromochloromethane	124-48-1	0.13	10		10
1,1,2-Trichloroethane	79-00-5	0.2	10	0.186	10
Benzene	71-43-2	0.34	10	0.208	10
Trans-1,3-Dichloropropene	10061-02-6	NA	10	0.251	10
Isopropylbenzene	98-82-8	660	10	0.270	10
Bromoform	75-25-2	8.5	10	0.227	10
4-Methyl-2-Pentanone	108-10-1	160	10	0.567	10
2-Hexanone	591-78-6	NA	10	0.335	10
Tetrachlorethene	127-18-4	0.66	10	0.452	10
1,1,2,2-Tetrachlorethene	79-34-5	0.055	10	0.390	10
Toluene	108-88-3	720	10	0.339	10
1,2-Dibromoethane	106-93-4	0.00076	10		10
Chlorobenzene	108-90-7	110	10	0.161	10
Ethylbenzene	100-41-4	2.9	10	0.267	10

TABLE 4-2A (cont.)

GROUNDWATER – VOLATILE ORGANIC TARGET ANALYTES, METHOD 8260B
 DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
 SURFACE WARFARE OFFICERS SCHOOL
 NAVAL STATION, NEWPORT, RHODE ISLAND
 PAGE 2 OF 2

Analytes	CAS Number	Project Action Limit (µg/L) ⁽¹⁾	Project Quantitation Limit (µg/L)	Achievable Laboratory Limits	
				MDLs ⁽³⁾ (µg/L)	QLs (µg/L)
Styrene	100-42-5	1600	10	0.409	10
Total Xylenes	1330-20-7	210	10	0.546	10
1,3-Dichlorobenzene	541-73-1	5.5	10	0.302	10
1,4-Dichlorobenzene	106-46-7	0.5	10	0.161	10
1,2-Dichlorobenzene	95-50-1	370	10	0.181	10
1,2-Dibromo-3-chloropropane	96-12-8	0.048	10	0.569	10
1,2,4-Trichlorobenzene	120-82-1	190	10	0.743	10

Notes:

NA Not applicable

(1) Region IX Preliminary Remediation Goals for Tap Water, unless otherwise specified

(2) Rhode Island GB Groundwater Objectives

(3) MDL from Alpha Analytical

TABLE 4-2B
GROUNDWATER – SEMIVOLATILE ORGANIC TARGET ANALYTES, METHOD 8270
DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/L) ⁽¹⁾	Project Quantitation Limit (µg/L)	Achievable Laboratory Limits	
				MDLs ⁽²⁾	QLs (µg/L)
Benzaldehyde	100-52-7	3600	10	NA	10
Phenol	108-95-2	22000	10	1.11	10
Bis-(2-Chloroethyl) ether	111-44-4	0.0098	10	1.34	10
2-Chlorophenol	95-57-8	30	10	2.72	10
2-Methylphenol	95-48-7	1800	10	1.97	10
2,2-oxybis(1-Chloropropane)	108-60-1	0.27	10	NA	10
Acetophenone	98-86-2	0.042	10	NA	10
4-Methylphenol	106-44-5	180	10	1.90	10
N-Nitroso-di-n propylamine	621-64-7	0.0096	10	0.64	10
Hexachloroethane	67-72-1	4.8	10	0.67	10
Nitrobenzene	98-95-3	3.4	10	0.69	10
Isophorone	78-59-1	71	10	0.80	10
2-Nitrophenol	88-75-5	NA	10	2.90	10
2,4-Dimethylphenol	105-67-9	730	10	2.59	10
Bis(2-Chloroethoxy) methane	111-91-1	NA	10	1.15	10
2,4-Dichlorophenol	120-83-2	110	10	2.24	10
Naphthalene	91-20-3	6.2	10	1.17	10
4-Chloroaniline	106-47-8	150	10	3.15	10
Hexachlorobutadiene	87-68-3	0.86	10	0.63	10
Caprolactam	105-60-2	18000	10	NA	10
4-Chloro-3-methylphenol	59-50-7	NA	10	NA	10
2-Methylnaphthalene	91-57-6	NA	10	3.21	10
Hexachlorocyclopentadiene	77-47-4	260	10	0.45	10
2,4,6-Trichlorophenol	88-06-2	3.6	10	2.14	10
2,4,5-Trichlorophenol	95-95-4	3600	25	2.05	25
1,1'-Biphenyl	92-52-4	300	10	1.15	10
2-Chloronaphthalene	91-58-7	490	10	3.21	10
2-Nitroaniline	88-74-4	1.0	25	1.08	25
Dimethylphthalate	131-11-3	360000	10	1.26	10
2,6-Dinitrotoluene	606-20-2	36	10	1.46	10
Acenaphthylene	208-96-8	NA	10	1.20	10
3-Nitroaniline	99-09-2	NA	25	3.72	25
Acenaphthene	83-32-9	370	10	1.32	10
2,4-Dinitrophenol	51-28-5	73	25	2.33	25
4-Nitrophenol	100-02-7	290	25	1.94	25
Dibenzofuran	132-64-9	24	10	2.49	10
2,4-Dinitrotoluene	121-14-2	73	10	1.45	10
Diethylphthalate	84-66-2	29000	10	1.24	10
Fluorene	86-73-7	240	10	1.18	10
4-Chlorophenyl-phenyl ether	7005-72-3	NA	10	0.86	10
4-Nitroaniline	100-01-6	NA	25	2.67	25
4,6-Dinitro-2-methylphenol	534-52-1	NA	25	2.30	25

TABLE 4-2B (cont.)
GROUNDWATER – SEMIVOLATILE ORGANIC TARGET ANALYTES, METHOD 8270
DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION, NEWPORT, RHODE ISLAND
PAGE 2 OF 2

Analytes	CAS Number	Project Action Limit (µg/L) ⁽¹⁾	Project Quantitation Limit (µg/L)	Achievable Laboratory Limits	
				MDLs ⁽²⁾	QLs (µg/L)
N-Nitroso diphenylamine	86-30-6	14	10	NA	10
4-Bromophenyl-phenylether	101-55-3	NA	10	1.06	10
Hexachlorobenzene	118-74-1	0.042	10	1.21	10
Atrazine	1912-24-9	0.3	10	NA	10
Pentachlorophenol	87-86-5	0.56	25	2.44	25
Phenanthrene	85-01-8	NA	10	1.24	10
Anthracene	120-12-7	1800	10	1.17	10
Carbazole	86-74-8	3.4	10	1.59	10
Di-n-butylphthalate	84-74-2	3600	10	1.32	10
Fluoranthene	206-44-0	1500	10	1.29	10
Pyrene	129-00-0	180	10	1.33	10
Butylbenzylphthalate	85-68-7	7300	10	0.78	10
3,3'-Dichlorobenzidine	91-94-1	0.15	10	3.18	10
Benzo (a) anthracene	56-55-3	0.092	10	1.28	10
Chrysene	218-01-9	9.2	10	1.19	10
bis(2-Ethylhexyl) phthalate	117-81-7	4.8	10	1.50	10
Di-n-octylphthalate	117-84-0	730	10	1.47	10
Benzo (b) fluoroanthene	205-99-2	0.092	10	1.25	10
Benzo (k) fluoroanthene	207-08-9	0.92	10	1.40	10
Benzo (a) pyrene	50-32-8	0.0092	10	1.41	10
Indeno (1,2,3-cd)-pyrene	193-39-5	0.092	10	1.45	10
Dibenzo (a,h)-anthracene	53-70-3	0.0092	10	1.28	10
Benzo (g,h,i) perylene	191-24-2	NA	10	1.30	10

Notes

NA Not applicable

(1) Region IX Preliminary Remediation Goals for Tap Water

(2) MDL from Alpha Analytical

TABLE 4-2C
GROUNDWATER – PESTICIDE/PCB TARGET ANALYTES, METHOD 8081/8082
DRAFT WORK PLAN – STUDY AREA SCREENING EVALUATION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/L) ⁽¹⁾	Project Quantitation Limit (µg/L)	Achievable Laboratory Limits	
				MDLs ⁽²⁾ (µg/L)	QLs (µg/L)
alpha-BHC	319-84-6	0.011	0.050	0.005	0.050
beta-BHC	319-85-7	0.037	0.050	0.005	0.050
delta-BHC	319-86-8	NA	0.050	0.009	0.050
gamma-BHC	58-89-9	0.052	0.050	0.005	0.050
Heptachlor	76-44-8	3.6 ⁽³⁾	0.050	0.006	0.050
Aldrin	309-00-2	0.004	0.050	0.006	0.050
Heptachlor epoxide	1024-57-3	3.6 ⁽³⁾	0.050	0.006	0.050
Endosulfan I	959-98-8	NA	0.050	0.005	0.050
Dieldrin	60-57-1	0.0042	0.10	0.011	0.10
4,4'-DDE	72-55-9	0.2	0.10	0.013	0.10
Endrin	72-20-8	11	0.10	0.011	0.10
Endosulfan II	33213-65-9	220	0.10	0.013	0.10
4,4'-DDD	72-54-8	0.28	0.10	0.011	0.10
Endosulfan sulfate	1031-07-8	NA	0.10	0.013	0.10
4,4'-DDT	50-29-3	0.2	0.10	0.011	0.10
Methoxychlor	72-43-5	NA	0.50	0.057	0.50
Endrin ketone	53494-70-5	NA	0.10	0.013	0.10
Endrin aldehyde	7421-93-4	NA	0.10	0.014	0.10
alpha-Chlordane	5103-71-9	0.2	0.050	0.006	0.050
gamma-Chlordane	5103-74-2	0.2	0.050	0.006	0.050
Toxaphene	8001-35-2	0.061	5.0	0.078	5.0
Aroclor-1016	12674-11-2	1.0	1.0	0.050	1.0
Aroclor-1221	11104-28-2	0.034	2.0		2.0
Aroclor-1232	11141-16-5	0.034	1.0		1.0
Aroclor-1242	53469-21-9	0.034	1.0	0.050	1.0
Aroclor-1248	12672-29-6	0.034	1.0		1.0
Aroclor-1254	11097-69-1	0.034	1.0		1.0
Aroclor-1260	11096-82-5	0.034	1.0	0.040	1.0

Notes:

NA Not applicable/Not available

(1) Region IX Preliminary Remediation Goals for Tap Water

(2) MDL from Alpha Analytical

(3) RIDEM UCL for GA Groundwater

TABLE 4-2D
GROUNDWATER – INORGANIC TARGET ANALYTES
DRAFT WORK PLAN - STUDY AREA SCREENING EVALUATION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/L) ⁽¹⁾	Project Quantitation Limit (µg/L)	Achievable Laboratory Limits	
				MDLs ⁽³⁾	QLs (µg/L)
Aluminum	7429-90-5	36000	200	0.0192	200
Antimony	7440-36-0	15	60	0.0023	60
Arsenic	7440-38-2	0.045	10	0.0020	10
Barium	7440-39-3	2600	200	0.0002	200
Beryllium	7440-41-7	73	5	0.0008	5
Cadmium	7440-43-9	18	5	0.0002	5
Calcium	7440-70-2	NA	5000	0.0013	5000
Chromium	7440-47-3	100 ⁽²⁾	10	0.0006	10
Cobalt	7440-48-4	730	50	0.0005	50
Copper	7440-50-8	1500	25	0.0012	25
Iron	7439-89-6	11000	100	0.0270	100
Lead	7439-92-1	15 ⁽²⁾	3	0.0011	3
Magnesium	7439-95-4	NA	5000	0.0045	5000
Manganese	7439-96-5	880	15	0.0002	15
Mercury	7439-97-6	1.1	0.2	0.012	0.2
Nickel	7440-02-0	100 ⁽²⁾	40	0.0009	40
Potassium	7440-09-7	NA	5000	0.2702	5000
Selenium	7782-49-2	180	5	0.0018	5
Silver	7440-22-4	180	10	0.0007	10
Sodium	7440-23-5	NA	5000	0.5148	5000
Thallium	7440-28-0	2.4	10	0.0026	10
Vanadium	7440-62-2	260	50	0.0009	50
Zinc	7440-66-6	11000	20	0.0007	20

Notes

NA Not applicable/Not Available

(1) Region IX Preliminary Remediation Goals for Tap Water

(2) Rhode Island GA Groundwater Objectives

(3) MDL from Alpha Analytical

Source blanks will be designated such that they can clearly be identified as source blanks. The designation must be able to be referenced to the source (e.g. DIUF or HPLC water) using the field paperwork.

Source Blanks: SWOS-A-DIUF-SB##

Rinsate blanks will be identified using the code for the sample for which the tool was last used, the identifier (RB), and its chronological number.

Rinsate Blanks: SWOS-A-SB01-0204-RB##

Trip blanks will be designated so that they can clearly be identified as aqueous trip blanks using an identifier (TB) and its chronological number.

Trip Blanks: SWOS-A-TB##

Matrix spike samples are simply marked as Lab QC in the "Remarks" section of the chain of custody Record form

4.4.2 Sample Chain of Custody

Custody of samples must be maintained and documented at all times. To ensure the integrity of a sample from collection through analysis, an accurate written record is necessary to trace the possession and handling of the sample. This documentation is referred to as the "chain of custody". Chain of custody begins when samples are collected in the field, and is maintained by storing the samples in secure areas until custody can be passed on. All samples will be accompanied by a chain-of-custody form that will describe the analytical parameters, and the persons who are responsible for its integrity.

Samples will be placed on ice and attended by TtNUS personnel or placed in locked vehicles or designated storage areas until analysis or shipment to an off-site laboratory. Chain-of-custody procedures are described in further detail in the SOPs presented in Appendix B of this work plan.

4.5 CALIBRATION PROCEDURES

Field equipment normally requiring calibration will be calibrated and operated in accordance with the manufacturer's instructions and manuals. A log will be kept on site, documenting the periodic calibration

results for each field instrument. Field equipment will be calibrated in the morning, and will be checked in the evening.

Calibration procedures for laboratory equipment used in the analysis of environmental samples will be performed in accordance with NFESC requirements and contract requirements under the Master Services Agreement (MSA) and the laboratory specifications i.e., CLP requirements for level IV data reports.

4.6 LABORATORY ANALYSIS

Samples collected will be analyzed for various parameters described in previous sections and listed in Table 3-1 and 3-3.

The environmental samples collected for laboratory analysis during the field investigation will be analyzed by a laboratory previously approved by the Navy. Standard EPA analytical procedures will be employed, as depicted in Table 3-3. Validation of data equivalent to EPA Region I Tier II Validation will be performed as is appropriate for data used for evaluation of risk under CERCLA described in Section 2.6 of this work plan.

4.7 DATA REDUCTION, REVIEW, AND REPORTING

Laboratory analytical data will be reviewed by qualified TtNUS technical staff. Laboratory data will undergo a data validation equivalent to EPA Region I Tier II validation. Data validation memoranda will be prepared and submitted to the project manager as a part of that activity. Data validation procedures are described in Section 4.0 of this work plan.

Field data will be periodically reviewed by technical lead personnel and the TtNUS project manager to ensure that the data that is collected is well documented, clearly described, and meets a standard appropriate for the investigation and its ultimate use.

4.8 INTERNAL QUALITY CONTROL

Section 4.2 discussed the types and frequency of quality control samples that will be prepared during the field investigation activities for those samples to undergo laboratory analysis. The quantities of the various types of the QC samples are shown in Table 3-4. Laboratory analysis will follow the QC criteria described in the analytical procedures.

4.9 PERFORMANCE AND SYSTEM AUDITS

System audits will be performed as appropriate to ensure that the work is being implemented in accordance with the approved project SOPs and in an overall satisfactory manner.

- The FOL will supervise and on a daily basis check to ensure that the equipment is thoroughly decontaminated, samples are collected and handled properly, and the field work is accurately and neatly documented.
- The data reviewer(s) will review the data and will check that the data was obtained through the approved methodology, and that the appropriate level of QC effort and reporting were conducted. The data validation effort will be supervised by the TtNUS CLEAN Quality Assurance Manager or designee.
- The PM will oversee the FOL and data reviewer, and check that management of the acquired data proceeds in an organized and expeditious manner.

4.10 DATA ASSESSMENT PROCEDURES

The following paragraphs describe the procedures used to evaluate data prior to inclusion and description in the deliverable reports described elsewhere in this work plan.

4.10.1 Representativeness, Accuracy, and Precision

All laboratory data generated in the investigation will be assessed for representativeness, accuracy, and precision, as described in Section 4.1. The completeness of the data will also be assessed by comparing the acquired data to the project objectives to see that these objectives are being addressed and met. The specific information used to determine data precision, accuracy, and completeness will be provided in the laboratory data packages.

The PARCC parameter assessment will be conducted by qualified TtNUS personnel. The representativeness of the data will be assessed by determining if the data are consistent with known or anticipated chemical conditions and accepted principles.

Field measurements will be checked for completeness of procedures and documentation of procedures and results.

Precision and accuracy will be determined using replicate samples and blank and spiked samples, respectively. PARCC parameters are addressed in more detail in Section 4.1.

4.10.2 Data Validation

Samples will be analyzed for parameters described on Table 3-3 of this work plan. The VOC and SVOC sample data will be validated using a Tier II validation protocol in accordance with Functional Guidelines for Evaluating Environmental Analyses (U.S. EPA, December 1996). The pesticide/PCB sample data will be validated using a Tier II validation protocol in accordance with Region I, EPA Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses (U.S. EPA, November 1988). The TAL metals analytical data will be validated using a Tier II validation protocol in accordance with Region I, EPA-NE Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses (modified February 1989). Use of these validation protocols is allowed under the NFESC (formerly NEESA) guidelines and is described in the Navy Installation Restoration Laboratory Quality Assurance Guide, Interim Document (revised February 1996), and the NEESA 20.2047B; June 1988 guidelines.

This level of validation is appropriate for data used for evaluation of risk under CERCLA described in Section 2.6 of this work plan.

4.11 CORRECTIVE ACTION

The QA program will enable problems to be identified, controlled, and corrected. Potential problems may involve non-conformance with the SOPs and/or analytical procedures established for the project, or other unforeseen difficulties. Any person identifying an unacceptable condition will notify the FOL and the PM. The PM, with the assistance of the Quality Assurance Manager and the project QA/QC officer, will be responsible for developing and initiating appropriate corrective action and verifying that the corrective action has been effective.

Corrective actions may include re-sampling and/or re-analysis of samples or modifying project procedures. If warranted by the severity of the problem (for example, if a change in the approved work plan is required), the Navy will be notified in writing and their approval will be obtained prior to implementing any change. Additional work that is dependent on a nonconforming activity will not be performed until the source of the problem has been addressed.

4.12 DOCUMENTATION

A bound/weatherproof field logbook will be maintained by the FOL. The FOL or designee will record all information related to sampling or field activities. This information may include sampling time, weather conditions, unusual events, field measurements, description of photographs, etc. The site logbook maintained by the FOL will contain a summary of the day's activities and will reference any additional field logbooks when applicable.

At the completion of field activities, the FOL will submit to the PM all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, etc. The PM will ensure that these materials are entered into the project file.

5.0 REPORTING

Following the completion of the field sampling and analytical work described in Section 3 of this work plan, the results of the information collected will be described in the form of a Study Area Screening Evaluation (SASE) report. The SASE report will contain eight major sections (detailed in the sections below), to reflect the general outline of a Remedial Investigation report.

It is the intent of the Navy to provide the draft report with a recommendation for or against performance of a remedial investigation and the next tiers of a risk assessment. Such a recommendation will be based on the type, concentrations, and likely origins of chemicals that are found to exceed the risk based criteria. It is assumed that if the reviewers do not agree with the Navy's recommendation, a discussion can be held at that time to determine an agreeable course of action.

5.1 SASE REPORT

Section 1.0 of the SASE report will describe the site history, background, and purpose of the report. The site background sections will include information from the Phase I Environmental Site Assessment of the Surface Warfare Officers School site that was published in July 2001 as well as from the Final Report and Risk Assessment for Worker Exposure at the SWOS Site. Any additional background information discovered during this investigation will be described in detail and incorporated into the site background section.

Section 2.0 of the SASE report will describe the site investigations which are the focus of this work plan. Specifically, this section will be based on Section 3.0 of this work plan and on the modifications of the field work, if any are made, during the period of activity.

Section 3.0 will describe the physical characteristics of the study area as they are observed at the time of the investigation. This will include the major site surface features (buildings, roadways, fences, etc). The site geology and hydrogeology will be described as determined by subsurface explorations performed. Figures will be prepared depicting aerial and/or cross sectional views of site features including: geology, maximum and minimum water table elevations and depth to bedrock. A shallow groundwater map will be created using water table elevations from both SWOS and OFFTA wells to help determine the groundwater flow direction in the area.

Section 4.0 of the SASE report will describe the contaminants found in various media during the investigations described in this work plan. This section will be based on the results of the activities described in Section 3.0 of this work plan and Section 2.0 of the SASE report. Summary tables of

analytical data will be included for all of the matrices sampled. During the field work, source areas identified or some of those originally targeted areas may be eliminated. All the chemical analytical data generated from the field work will be summarized in this section. Comparisons of soil analytical results will be made to background concentrations.

Figures to be included in Section 4.0 of the SASE report may include aerial and/or cross-sectional views of the site. As appropriate, pertinent information such as concentration of contaminants, location of samples, etc, will be included in the figures.

Section 5.0 of the SASE report will describe the expected transport mechanisms available to the primary site contaminants. This effort will focus on development of the first tiers of the conceptual site model presenting site contaminants, background conditions and contaminant fate. The conceptual model will be supported by discussion on the potential chemical and physical processes that influence movement and decomposition of site specific contaminants

Section 6.0 will be composed of a screening-level Human Health Risk Evaluation (see Section 5.2 of this work plan).

Section 7.0 of the SASE report will describe conclusions of the report. The conclusions of the SASE will be limited to an assessment of the presence or absence of site specific contaminants, discussion of a possible relationship of the adjacent OFFTA site (Site 09) to the SWOS site and a summary of exceedences of human health risk-based criteria (RBCs). Finally, a recommendation will be made for continuation of work at this site for a Remedial Investigation.

5.2 HUMAN HEALTH RISK EVALUATION

Section 6.0 of the SASE report will consist of a limited human health risk evaluation as described below.

Chemical concentrations detected in soil will be compared with Region IX industrial PRGs and RIDEM direct exposure criteria for industrial-use soil. Chemical concentrations in groundwater will be compared with MCLs, Region IX PRGs for tap water, and RIDEM criteria for GB groundwater, which is the classification for this site.

Contaminants detected will be eliminated as COPCs at the site if the maximum concentration for the chemical is less than applicable screening criteria, and if the representative concentrations are below background concentrations.

OFFTA
Background
Data

Chemicals that lack toxicity values will be evaluated qualitatively. The qualitative evaluation will include a discussion of the presence of the chemical at the specific sample stations where it was detected, a discussion of the toxicity of similar chemicals found at these stations or elsewhere at the site (if applicable, and a determination of impact of this chemical on the risk assessment results (i.e., will the omission of this chemical from a quantitative risk assessment, if one were performed, be significant or not).

Chemicals that are breakdown products of selected COPCs or chemicals that are in the same family as selected COPCs (e.g. carcinogenic PAHs and PCBs) will also be included as COPCs. The final list of COPCs will be provided for discussion regarding the need for further risk analysis.

6.0 REFERENCES

- Ames and Whitaker Architects. 1996. Demolition of Brig- Building 149, Coasters Harbor Island, Site Development Plan. NETC Drawing Number 31490-311. July.
- Ames and Whitaker Architects. 1996. Demolition of Brig- Building 149, Coasters Harbor Island, Hazardous Materials Abatement. NETC Drawing Number 31491-311. July.
- Cull and Robinson Architects Engineers. 1951. 75 Man Brig- Naval Training Station, Coasters Harbor Island, Naval Base- Newport, Rhode Island Plot Plan and Location Plan. NETC Drawing Number 11169-118. December.
- Envirodyne Engineers, Inc. (EEI). 1983. Initial Assessment Study of the Naval Education and Training Center, Newport, Rhode Island. Contract No. N62474-82-C-8262. Naval Energy and Environmental Support Activity (NEESA) 13-024. March.
- Foster Wheeler Environmental Corporation. 2003. Final Report and Risk Assessment for Worker Exposure at the SWOS Site, Naval Station Newport, Portsmouth, Rhode Island. Contract No. N62472-99-D-0032. U.S. Navy Engineering Field Activity Northeast Remedial Action Contract (RAC). September.
- Hermes, O.D., L. P. Gromet, and D.P. Murray. 1994. Bedrock Geologic Map of Rhode Island. Rhode Island Map Series No. 1. Published by Office of Rhode Island State Geologist.
- Greca, F. (Department of the Navy). 2003. Letter to K. Keckler (USEPA) and P. Kulpa (RIDEM), RE: Proposed addition of a New Study Area Site to NAVSTA Newport Federal Facility Agreement. June.
- Naval Station Newport Restoration Advisory Board Meeting (RAD). 1999. Board Meeting Minutes. August.
- Naval Station Newport. 2001. Naval Station Newport Visitor's Information: Coddington Island Area Base Map. Internet site: <http://www.nsnpt.navy.mil/map/basemap.htm>. June 18.
- Schiner, G.R., and J.B. Gonthier. 1964. Ground-Water Map of the Prudence Island and Newport Quadrangles, Rhode Island. State of Rhode Island and Providence Plantations Water Resources Coordinating Board. GWM 20.
- State of Rhode Island Department of Environmental Management (RIDEM). 1995. Rules and Regulations for Groundwater Quality (Regulation 12-100-006). Division of Groundwater and Individual Sewage Disposal Systems. May.
- State of Rhode Island Department of Environmental Management (RIDEM). 1997. Water Quality Regulations Appendix A: Water Quality Classification Descriptions (Regulation EVM 112-88.97-1) Water Resources. August.
- Tetra Tech NUS (TtNUS). 2000. Background Soil Investigation for Old Fire Fighting Training Area, Naval Station Newport, Newport, Rhode Island. Contract No. N62472-90-D-1298. Northern Division Naval Facilities Engineering Command. August.
- TtNUS. 2000. Draft Final Remedial Investigation for Old Fire Fighting Training Area, Naval Station Newport, Newport, Rhode Island. Contract No. N62472-90-D-1298. Northern Division Naval Facilities Engineering Command. October.

TtNUS. 2002. Feasibility Study for Old Fire Fighter Training Area, Naval Station Newport, Newport, Rhode Island. Contract No. N62467-94-D-0888. Environmental Field Activity Northeast Naval Facilities Engineering Command. September.

TtNUS. 2001. Phase I Environmental Site Assessment for SWOS Building Site, Naval Station Newport, Newport, Rhode Island. Oak Point Associates, Biddeford, Maine. July.

U.S. Department of Agriculture (USDA). 1981. (Issued). Soil Conservation Service. Soil Survey of Rhode Island. Prepared in cooperation with the Rhode Island Agricultural Experiment Station.

U.S. Geological Survey (USGS). 1955 (photorevised in 1970 and 1975). Prudence Island Quadrangle, Rhode Island, 7.5 Minute Series (Topographic).

APPENDIX A
SITE SPECIFIC HEALTH AND SAFETY PLAN

APPENDIX B

TINUS STANDARD OPERATING PROCEDURES



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number	GH-1.5	Page	1 of 20
Effective Date	06/99	Revision	1
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Subject	BOREHOLE AND SAMPLE LOGGING		
Approved	D. Senovich <i>DS</i>		

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE	3
2.0 SCOPE	3
3.0 GLOSSARY	3
4.0 RESPONSIBILITIES	3
5.0 PROCEDURES	3
5.1 MATERIALS NEEDED	3
5.2 CLASSIFICATION OF SOILS	3
5.2.1 USCS Classification	6
5.2.2 Color	6
5.2.3 Relative Density and Consistency	6
5.2.4 Weight Percentages	7
5.2.5 Moisture	10
5.2.6 Stratification	10
5.2.7 Texture/Fabric/Bedding	10
5.2.8 Summary of Soil Classification	10
5.3 CLASSIFICATION OF ROCKS	13
5.3.1 Rock Type	13
5.3.2 Color	16
5.3.3 Bedding Thickness	16
5.3.4 Hardness	16
5.3.5 Fracturing	16
5.3.6 Weathering	17
5.3.7 Other Characteristics	17
5.3.8 Additional Terms Used in the Description of Rock	18
5.4 ABBREVIATIONS	19
5.5 BORING LOGS AND DOCUMENTATION	19
5.5.1 Soil Classification	19
5.5.2 Rock Classification	23
5.5.3 Classification of Soil and Rock from Drill Cuttings	24
5.6 REVIEW	24
6.0 REFERENCES	24
7.0 RECORDS	25

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 2 of 20
	Revision 1	Effective Date 06/99

TABLE OF CONTENTS (Continued)

FIGURES

NUMBERS

PAGE

1	BORING LOG (EXAMPLE)	4
2	CONSISTENCY FOR COHESIVE SOILS	8
3	BEDDING THICKNESS CLASSIFICATION	10
4	GRAIN SIZE CLASSIFICATION FOR ROCKS	12
5	COMPLETED BORING LOG (EXAMPLE)	17

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 3 of 20
	Revision 1	Effective Date 06/99

1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist. Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used on site, the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 Materials Needed

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute hydrochloric acid (HCl)
- Ruler (marked in tenths and hundredths of feet)
- Hand Lens

5.2 Classification of Soils

All data shall be written directly on the boring log (Figure 1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

Subject

BOREHOLE AND SAMPLE LOGGING

Number

GH-1.5

Page

5 of 20

Revision

1

Effective Date

06/99

FIGURE 1 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS More Than Half of Material is LARGER Than No. 200 Sieve Size				FINE-GRAINED SOILS More Than Half of Material is SMALLER Than			
FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 2 Inches and Breaking Particles on Estimated Weights)		GROUP SYMBOL	TYPICAL NAMES	FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 2 Inches and Breaking Particles on Estimated Weights)			
				Identification Procedures on Particles Smaller Than No. 40 Sieve Size			
					DAY STRENGTH (Shrinkage Characteristics)	PLATYMOITY (Shrinkage to Shrinkage)	TOUGHNESS (Shrinkage to Plastic Limit)
GRAVELS (GW, GP, GM, GC)	CLEAN GRAVELS (Less Than 5% Fines)	GW	Well graded gravel, gravel-sand mixtures, little or no fines	SANDS AND CLAYS (Liquid Limit < 40)	Flow to Slight	Slight to Flow	None
		GP	Poorly graded gravel, gravel-sand mixtures, little or no fines		Medium to High	None to Very Sluggish	Medium
	GRAVELS WITH FINES (High % Fines)	GM	Silty gravel, poorly graded gravel-sand mixtures		Slight to Medium	Sluggish	Slight
		GC	Clayey gravel, poorly graded gravel-sand mixtures		Slight to Medium	Sluggish to Sluggish	Slight to Medium
SANDS (SW, SP, SM, SC)	CLEAN SANDS (Less Than 5% Fines)	SW	Well graded sand, gravelly sands, little or no fines	SANDS AND CLAYS (Liquid Limit > 40)	High to Very High	None	High
		SP	Poorly graded sand, gravelly sands, little or no fines		Medium to High	None to Very Sluggish	Slight to Medium
	SANDS WITH FINES (High % Fines)	SM	Silty sand, poorly graded sand-silt mixtures		Heavily laminated by color, odor, sponge test and frequency by blow count		
		SC	Clayey sand, poorly graded sand-silt mixtures				

Boundary classification: Soil possessing characteristics of two groups are designated by combining group symbols. For example, GW-GC, well graded gravel-sand mixtures with clay fines. All data are on Method 10.5. Standard.

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE, BLOWS/FOOT
Very Loose	0-4
Loose	5-10
Medium Dense	11-30
Dense	31-50
Very Dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNICOMPRESSIVE STRENGTH (TENSILE, FT.)	STANDARD PENETRATION RESISTANCE, BLOWS/FOOT	
Very Soft	Less than 0.25	0 to 2	Only present
Soft	0.25 to 0.50	2 to 4	Only present
Medium Soft	0.50 to 1.5	4 to 8	Can be present
Stiff	1.5 to 2.0	8 to 15	Usually present
Very Stiff	2.0 to 4.0	15 to 30	Usually present
Hard	More than 4.0	Over 30	Infrequent with

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)			ROCK BROKENNESS		
Descriptive Terms	Soundness or Bulk Effects	Fracture Effects	Descriptive Terms	Abbreviation	Rating
Soft	Only chipped	Cracks when pressed with hammer	Very Brittle	(V.B.)	0-2
Medium Soft	Can be chipped	Breaks (see below) mostly edges	Brittle	(B.)	2-4
Medium Hard	Can be crushed	Breaks (see below) sharp edges	Sticky	(S.)	4-6
Hard	Cannot be crushed	Breaks completely (see below) sharp edges	Adhesive	(A.)	7-10

LEGEND:

SOIL SAMPLES - TYPES

S-7 Spill Sample

S-7 D.D. Unconsolidated Sample

Q - Core Sample, Specify in Remarks

ROCK SAMPLES - TYPES

R-1 (Unconsolidated) Core (-3 MP D.D.)

R-2 (Unconsolidated) Core (-3 MP D.D.)

R - Core Sample, Specify in Remarks

WATER LEVELS

W-1
Water Level
at Date & DepthW-2
Water Level
at Date & Depth

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 6 of 20
	Revision 1	Effective Date 06/99

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (Continued).

This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse-grained soils shall be divided into rock fragments, sand, or gravel. The terms sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as "(1/4 inch Φ -1/2 inch Φ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer-grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split-barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.3. Those designations are:

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 7 of 20
	Revision 1	Effective Date 06/99

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140-pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Figure 2.

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength), or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are shown in Figure 2.

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
Trace	0 - 10 percent
Some	11 - 30 percent
Adjective form of the soil type (e.g., "sandy")	31 - 50 percent

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 8 of 20
	Revision 1	Effective Date 06/99

FIGURE 2

CONSISTENCY FOR COHESIVE SOILS

C nsistency	Standard Penetration Resistance (Blows per Foot)	Unconfined Compressive Strength (Tons/Sq. Foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented with difficulty by thumbnail

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 9 of 20
	Revision 1	Effective Date 06/99

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Figure 3.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 10 of 20
	Revision 1	Effective Date 06/99

FIGURE 3

BEDDING THICKNESS CLASSIFICATION

Thickness (metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	<1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 11 of 20
	Revision 1	Effective Date 06/99

5.3 Classification of Rocks

Rocks are grouped into three main divisions: sedimentary, igneous and metamorphic. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.
- Claystone - Very fine-grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine-grained rock. Fractures along bedding planes.
- Lim stone - Rock made up predominantly of calcite (CaCO_3). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

5.3.1 Rock Type

As described above, there are numerous types of sedimentary rocks. In most cases, a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Figure 4 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a claystone.

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 12 of 20
	Revision 1	Effective Date 06/99

FIGURE 4

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4 - 64 mm
Granules	2 - 4 mm
Very Coarse Sand	1 - 2 mm
Coarse Sand	0.5 - 1 mm
Medium Sand	0.25 - 0.5 mm
Fine Sand	0.125 - 0.25 mm
Very Fine Sand	0.0625 - 0.125 mm
Silt	0.0039 - 0.0625 mm

After Wentworth, 1922

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 13 of 20
	Revision 1	Effective Date 06/99

5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock color charts shall not be used unless specified by the Project Manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification (see Figure 3) will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).
- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.
- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.
- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the words "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2-inch spacing between fractures
- Broken (BR.) - 2-inch to 1-foot spacing between fractures
- Blocky (BL.) - 1- to 3-foot spacing between fractures
- Massive (M.) - 3 to 10-foot spacing between fractures

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 14 of 20
	Revision 1	Effective Date 06/99

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

$$RQD \% = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified).
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic).
- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 15 of 20
	Revision 1	Effective Date 06/99

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inches or less), probably continuous layer.
- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone – some shale seams."
- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone – few shale seams."
- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse-grained dark igneous rock.

The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine- to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 16 of 20
	Revision 1	Effective Date 06/99

5.4 Abbreviations

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine-grained
Tr - Trace		

5.5 Boring Logs and Documentation

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log has been provided as Figure 5.

The field geologist/engineer shall use this example as a guide in completing each boring log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided either on the back of the boring log or on a separate sheet, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology at 13.7 feet, shall be lined off at the proportional location between the 13- and 14-foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.
- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split-spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.
- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.
- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart on back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 17 of 20
	Revision 1	Effective Date 06/99

**FIGURE 5
COMPLETED BORING LOG (EXAMPLE)**



BORING LOG

Page 1 of 1

PROJECT NAME:	<u>NSB - SITE</u>	BORING NUMBER:	<u>SB/MW 1</u>
PROJECT NUMBER:	<u>9594</u>	DATE:	<u>3/8/96</u>
DRILLING COMPANY:	<u>SOILTEST CO.</u>	GEOLOGIST:	<u>SJ CONTI</u>
DRILLING RIG:	<u>CME-55</u>	DRILLER:	<u>R. ROCK</u>

Sample No. and Type or ROD	Depth (Feet) or Run No.	Blows / 6" or ROD (%)	Sample Recovery / Sample Length	Lithology Change (Depth) or Screened Interval	MATERIAL DESCRIPTION			U S C S *	Remarks	PID/FID Reading (ppm)			
					Soil Density/ Consistency or Rock Hardness	Color	Material Classification			Sample	Sample BZ	Boothole	Driller BZ
S-1 C 0800	0.0 2.0	7 9	1 1/2 2.0		M DENSE To BLK	BRN To BLK	SILTY SAND - SOME Rock Fr. TR BRICKS (FILL)	SM	MOIST SL. ORG. ODOR FILL TO 4'±	5	0	0	0
	4.0			4.0									
S-2 C 0810	5.0 6.0	5 8	2 1/2 2.0		M DENSE	BRN	SILTY SAND - TR FINE GRAVEL	SM	MOIST - W ODOR NAT. MATL. TOOK SAMPLE SB01-0406 FOR ANALYSIS	10	0	-	-
	8.0			7'± 8.0									
S-3 C 0820	9.0 10.0	6 17	1 1/2 2.0		DENSE	TAN BRN	FINE TO COARSE SAND TR.F. GRAVEL	SW	WET HIT WATER: 7'±	0	0	0	0
	12.0			12.0									
S-4 C 0830	13.0 14.0	7 5	1 1/2 2.0		STIFF	GRY	SILTY CLAY	CL	MOIST - WET	0	.5	-	-
	15.0			15.0									
				16.0	M HARD	BRN	SILTSTONE	VER	WEATHERED				
9/5 ①	17.0		4.0/5.0	18'					LO *JNTS @ 15.5 WATER STAINS @ 16.5, 17.1, 17.5	0	0	0	0
	20.0				HARD	GRY	SANDSTONE - SOME SILTSTONE	BR	DRILL H2O @ 17'± SET TEMP 6" CAS TO 15.5				
4/5 ②	21.0		5.0/5.0						SET 2"Ø PVC SCREEN 16'-25'	0	0	0	0
	25.0			25'					SAND 14-25 PELLETS 12-14				

* When rock coring, enter rock brokenness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

Remarks: CME-55 RIG, 4 1/4" ID HSA - 9" OD±
2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP
ALL CORE IN BEDROCK RUN (1) = 25 min, RUN (2) = 15 min

Converted to Well: Yes ☒ No ☐ Well I.D. #: MW-1

• 1-20Z
1-80Z
Drilling Area
Background (ppm): 0

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 18 of 20
	Revision 1	Effective Date 06/99

- Enter color of the material in the appropriate column.
- Describe material using the USCS. Limit this column for sample description only. The predominant material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:
 - Trace: 0 - 10 percent
 - Some: 11 - 30 percent
 - And/Or: 31 - 50 percent
- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.
- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.
- The following information shall be entered under the "Remarks" column and shall include, but is not limited by, the following:
 - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.
 - Angularity - describe angularity of coarse grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.
 - Particle shape - flat, elongated, or flat and elongated.
 - Maximum particle size or dimension.
 - Water level observations.
 - Reaction with HCl - none, weak, or strong.
- Additional comments:
 - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.
 - Indicate odor and Photoionization Detector (PID) or Flame Ionization Detector (FID) reading if applicable.
 - Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently constructed.
 - At the bottom of the page indicate type of rig, drilling method, hammer size and drop, and any other useful information (i.e., borehole size, casing set, changes in drilling method).

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 19 of 20
	Revision 1	Effective Date 06/99

- Vertical lines shall be drawn (as shown in Figure 5) in columns 6 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.
- Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent, and core recovery under the appropriate columns.
- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.
- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.
- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.
- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.
- Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.
- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:
 - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
 - Indicate calcareous zones, description of any cavities or vugs.
 - Indicate any loss or gain of drill water.
 - Indicate drop of drill tools or change in color of drill water.
- Remarks at the bottom of Boring Log shall include:
 - Type and size of core obtained.
 - Depth casing was set.
 - Type of rig used.
- As a final check the boring log shall include the following:
 - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.
 - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 20 of 20
	Revision 1	Effective Date 06/99

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5-foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date, etc.). Cuttings shall be closely examined to determine general lithology.
- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.
- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.
- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.
- Record this and any other useful information onto the boring log as provided in Figure 1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split-barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 Review

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs.
- Checking for conformance to the guideline.
- Checking to see that all information is entered in their respective columns and spaces.

6.0 REFERENCES

Unified Soil Classification System (USCS).

ASTM D2488, 1985.

Earth Manual, U.S. Department of the Interior, 1974.

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number	GH-2.8	Page	1 of 12
Effective Date	06/99	Revision	2
Applicability	Tetra Tech NUS, Inc.		
Prepared			
Subject	GROUNDWATER MONITORING WELL INSTALLATION		
Approved	D. Senovich <i>DS</i>		

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE	2
2.0 SCOPE	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES	2
5.0 PROCEDURES	3
5.1 EQUIPMENT/ITEMS NEEDED	3
5.2 WELL DESIGN	3
5.2.1 Well Depth, Diameter, and Monitored Interval	3
5.2.2 Riser Pipe and Screen Materials	5
5.2.3 Annular Materials	6
5.2.4 Protective Casing	7
5.3 MONITORING WELL INSTALLATION	7
5.3.1 Monitoring Wells in Unconsolidated Sediments	7
5.3.2 Confining Layer Monitoring Wells	8
5.3.3 Bedrock Monitoring Wells	8
5.3.4 Drive Points	8
5.3.5 Innovative Monitoring Well Installation Techniques	8
5.4 WELL DEVELOPMENT METHODS	9
5.4.1 Overpumping and Backwashing	9
5.4.2 Surging with a Surge Plunger	9
5.4.3 Compressed Air	9
5.4.4 High Velocity Jetting	9
6.0 RECORDS	10
7.0 REFERENCES	10
<u>ATTACHMENTS</u>	
A RELATIVE COMPATIBILITY OF RIGID WELL-CASING MATERIAL (PERCENT) / RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)	11
B COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION	12

Subject	GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 2 of 12
		Revision 2	Effective Date 06/99

1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 3 of 12
	Revision 2	Effective Date 06/99

5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well or piezometer:

- Health and safety equipment as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives and intended use for each monitoring well must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 4 of 12
	Revision 2	Effective Date 06/99

The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)
2	6.13
4	1.53
6	0.68

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 5 of 12
	Revision 2	Effective Date 06/99

If a well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells (for installation of high capacity pumps); however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "Schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength". Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 6 of 12
	Revision 2	Effective Date 06/99

shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium- to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets, extending to the surface. The grout effectively seals the remaining borehole annulus and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom upward, to prevent bridging, and to provide a better seal. In shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets/chips or cement grout. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 7 of 12
	Revision 2	Effective Date 06/99

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A protective casing which is level with the ground surface (flush-mounted) is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized lid is placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 Monitoring Well Installation

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 8 of 12
	Revision 2	Effective Date 06/99

The cement-bentonite grout is then mixed and tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5–10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen section is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be manually driven to depths exceeding 10 feet.

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 9 of 12
	Revision 2	Effective Date 06/99

5.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity and temperature taken during development may yield information (stabilized values) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

5.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

5.4.3 Compressed Air

Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus introducing air into the formation and reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method.

5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 10 of 12
	Revision 2	Effective Date 06/99

screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features, screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have an idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

7.0 REFERENCES

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Cosby, and J. Fryberger, 1981. Manual of Groundwater Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989.

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 11 of 12
	Revision 2	Effective Date 06/99

ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material						
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/ High Solids Content	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

- | | | | |
|----|---------------------|---|------------------|
| 1 | Teflon* | 5 | Lo-Carbon Steel |
| 2 | Stainless Steel 316 | 6 | Galvanized Steel |
| 3. | Stainless Steel 304 | 7 | Carbon Steel |
| 4 | PVC 1 | | |

* Trad mark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material								
	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton*	Silicone	Neoprene	Teflon*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/ High Solids Content	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

- | | | | |
|----|------------------------|---|------------------------|
| 1 | Teflon* | 5 | PE Conventional |
| 2 | Polypropylene (PP) | 6 | Plexiglas/Lucite (PMM) |
| 3. | PVC Flexible/PE Linear | 7 | Silicone/Neoprene |
| 4 | Viton* | | |

* Trademark of DuPont

Source: Barcelona et al., 1983

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 12 of 12
	Revision 2	Effective Date 06/99

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned if organics will be subsequently sampled.	Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

* See also Attachment A.

**U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I**

**LOW STRESS (low flow) PURGING AND SAMPLING
PROCEDURE FOR THE COLLECTION OF
GROUND WATER SAMPLES
FROM MONITORING
WELLS**



**July 30, 1996
Revision 2**

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE
FOR THE COLLECTION OF GROUND WATER SAMPLES
FROM MONITORING WELLS

I. SCOPE & APPLICATION

This standard operating procedure (SOP) provides a general framework for collecting ground water samples that are indicative of mobile organic and inorganic loads at ambient flow conditions (both the dissolved fraction and the fraction associated with mobile particulates). The SOP emphasizes the need to minimize stress by low water-level drawdowns, and low pumping rates (usually less than 1 liter/min) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed primarily at sampling monitoring wells that can accept a submersible pump and have a screen, or open interval length of 10 feet or less (this is the most common situation). However, this procedure is flexible and can be used in a variety of well construction and ground-water yield situations. Samples thus obtained are suitable for analyses of ground water contaminants (volatile and semi-volatile organic analytes, pesticides, PCBs, metals and other inorganics), or other naturally occurring analytes.

This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). For this the reader may wish to check: Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation; C.K. Smoley (CRC Press), Boca Raton, Florida and U.S. Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance; Washington, DC (EPA/530-R-93-001).

The screen, or open interval of the monitoring well should be optimally located (both laterally and vertically) to intercept existing contaminant plume(s) or along flowpaths of potential contaminant releases. It is presumed that the analytes of interest move (or potentially move) primarily through the more permeable zones within the screen, or open interval.

Use of trademark names does not imply endorsement by U.S.EPA but is intended only to assist in identification of a specific type of device.

II. EQUIPMENT

A. Extraction device

Adjustable rate, submersible pumps are preferred (for example, centrifugal or bladder pump constructed of stainless steel or Teflon).

Adjustable rate, peristaltic pumps (suction) may be used with caution. Note that EPA guidance states: "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" (EPA/540/P-87/001, 1987, page 8.5-11).

The use of inertial pumps is discouraged. These devices frequently cause greater disturbance during purging and sampling and are less easily controlled than the pumps listed above. This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

B. Tubing

Teflon or Teflon lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for inorganics analyses. However, these materials should be used with caution when sampling for organics. If these materials are used, the equipment blank (which includes the tubing) data must show that these materials do not add contaminants to the sample.

Stainless steel tubing may be used when sampling for VOCs, SVOCs, pesticides, and PCBs. However, it should be used with caution when sampling for metals.

The use of 1/4 inch or 3/8 inch (inner diameter) tubing is preferred. This will help ensure the tubing remains liquid filled when operating at very low pumping rates.

Pharmaceutical grade (Pharmed) tubing should be used for the section around the rotor head of a peristaltic pump, to minimize gaseous diffusion.

C. Water level measuring device(s), capable of measuring to 0.01 foot accuracy (electronic "tape", pressure transducer). Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use

III. PRELIMINARY SITE ACTIVITIES

Check well for security damage or evidence of tampering, record pertinent observations.

Lay out sheet of clean polyethylene for monitoring and sampling equipment.

Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook.

A synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) be measured the day before, in order to allow for re-settlement of any particulates in the water column. If measurement of total well depth is not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe are usually not needed unless analytical data or field head space information signal a worsening situation. Note: procedures for collection of LNAPL and DNAPL samples are not addressed in this SOP.

IV. PURGING AND SAMPLING PROCEDURE

Sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

1. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. The Sampling and Analysis Plan should specify the sampling depth, or provide criteria for selection of intake depth for each well (see Section I). If possible keep the pump intake at least two

3b. Subsequent Low Stress Sampling Events

After synoptic water level measurement round, check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). Perform purging operations as above.

4. Monitor Indicator Field Parameters

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, Eh, DO) every three to five minutes (or less frequently, if appropriate). Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at three (3) to five (5) minute intervals, are within the following limits:

- turbidity (10% for values greater than 1 NTU),
- DO (10%),
- specific conductance (3%),
- temperature (3%),
- pH (± 0.1 unit),
- ORP/Eh (± 10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell and may also cause an underestimation of turbidity values measured after the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities.

The flow-through-cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times. If two flow-through-cells are used in series, the one containing the dissolved oxygen probe should come first (this parameter is most susceptible to error if air leaks into the system).

Label each sample as collected. Samples requiring cooling (volatile organics, cyanide, etc.) will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

6. Post Sampling Activities

If recording pressure transducer is used, remeasure water level with tape.

After collection of the samples, the pump tubing may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth is optional after the initial low stress sampling event. However, it is recommended if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

V. DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the well) will be decontaminated by one of the procedures listed below.

Procedure 1

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is

may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one set per VOC sample cooler.

Field duplicate.

Matrix spike.

Matrix spike duplicate.

Equipment blank.

Trip blank (VOCs).

Temperature blank (one per sample cooler).

Equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank will only include the pump in subsequent sampling rounds.

Collect samples in order from wells with lowest contaminant concentration to highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

Field duplicates are collected to determine precision of sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

If split samples are to be collected, collect split for each analyte group in consecutive order (VOC original, VOC split, etc.). Split sample should be as identical as possible to original sample.

All monitoring instrumentation shall be operated in accordance with EPA analytical methods and manufacturer's operating instructions. EPA analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846 with exception of Eh, for which the manufacturer's instructions are to be followed. Instruments shall be calibrated at the beginning of each day. If a measurement falls outside the calibration range, the instrument should be re-calibrated so that all measurements fall within the calibration range. At the end of each day, check calibration to verify that instruments remained in calibration. Temperature measuring equipment, thermometers and thermistors, need not be calibrated to the above frequency. They should be checked for accuracy prior to field use according to EPA Methods and the manufacturer's instructions.

EXAMPLE (Minimum Requirements)
Well PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Page of

Location (Site/Facility Name)

Well Number

Field Personnel

Sampling Organization

Identify MP

Depth to _____ / _____ of screen
(below MP)

(below MP) top bottom

Pump Intake at (ft. below MP)

Purging Device; (pump type)

[illegible]

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. μ Siemens per cm (same as μ mhos/cm) at 25°C.
3. Oxidation reduction potential (stand in for Eh).



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number GH-2.5	Page 1 of 9
Effective Date 06/99	Revision 1
Applicability Tetra Tech NUS, Inc.	
Prepared Earth Sciences Department	
Approved D. Senovich <i>DS</i>	

Subject GROUNDWATER CONTOUR MAPS AND FLOW
DETERMINATIONS

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE	2
2.0 SCOPE	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES	3
5.0 PROCEDURES	3
5.1 POTENTIOMETRIC SURFACE MAPPING	3
5.1.1 Selection of Wells	3
5.1.2 Water Level Measurements	3
5.1.3 Construction of Equipotential Lines	4
5.1.4 Determination of Groundwater-Flow Direction	4
5.2 GROUNDWATER FLOW CONSIDERATIONS	5
5.3 DETERMINATION OF FLOW RATE	5
6.0 REFERENCES	7

ATTACHMENTS

A	GENERALIZED POROSITY AND HYDRAULIC CONDUCTIVITY VALUES FOR GEOLOGIC MATERIALS	9
---	--	---

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5	Page 2 of 9
	Revision 1	Effective Date 06/99

1.0 PURPOSE

The purpose of this procedure is to provide a basic understanding of developing contour maps and the approaches used to identify and quantify the direction and rate of groundwater flow and contaminant plume movement.

2.0 SCOPE

This procedure provides only a general overview of the field techniques, mathematical and physical relationships and data handling procedures used for determining groundwater flow direction and rate. The references identified herein can provide a more complete explanation of particular methods cited, as well as a more comprehensive discussion on the interpretation of hydrogeologic data.

3.0 GLOSSARY

Aquifer - A geologic formation capable of transmitting usable quantities of groundwater to a well or other discharge point.

Aquitard - A geologic formation which retards the flow of groundwater due to its low permeability.

Confined Aquifer - An aquifer that is overlain and underlain by zones of lower permeability (aquitards). If the aquifer is "artesian," the potentiometric head of the aquifer at a given point is higher than the top of the zone comprising the aquifer at that point.

Equipotential Line - A line connecting points of equal elevation of the water table or potentiometric surface. Equipotential lines on the water table are also called water table contour lines.

Flow Line - A flow line indicates the direction of groundwater movement within the saturated zone. Flow lines are drawn perpendicular to equipotential lines.

Flow Net - A diagram of groundwater flow showing flow lines and equipotential lines.

Hydraulic Conductivity (K) - A quantitative measure of the ability of porous material to transmit water. Volume of water that will flow through a unit cross sectional area of porous material per unit time under a head gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid.

Hydraulic Gradient (i) - The rate of change of hydraulic head per unit distance of flow at a given point and in the downgradient direction.

Hydraulic Head - The height to which water will rise inside a well casing, equal to the elevation head plus the pressure head. In a well screened across the water table, hydraulic head equals the elevation head, as the pressure head equals 0. In wells screened below the water table in an unconfined aquifer or screened at any interval within a confined aquifer, the head is the sum of the elevation of the aquifer (the elevation head) and the fluid pressure of the water confined in the aquifer (the pressure head).

Potentiometric (piezometric) Surface - A hypothetical surface that coincides with the static level of the water in an aquifer (i.e., the maximum elevation to which water will rise in a well or piezometer penetrating the aquifer). The term "potentiometric surface" is usually applied to confined aquifers, although the water table is the potentiometric surface of an unconfined aquifer.

Unconfined Aquifer - An aquifer in which the water table forms the upper boundary.

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5	Page 3 of 9
	Revision 1	Effective Date 06/99

Water Table - The surface in the groundwater system at which the fluid pressure is equal to atmospheric pressure (i.e., the net pressure head is zero) and below which all strata are saturated with water.

4.0 RESPONSIBILITIES

Project Hydrogeologist - The project hydrogeologist has overall responsibility for obtaining water level measurements and developing groundwater contour maps. The hydrogeologist (with the concurrence of the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number of data points needed and which wells shall be used for a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - All supporting field personnel must have a basic familiarity with the equipment and procedures involved in obtaining water levels, and must be aware of any project-specific requirements.

5.0 PROCEDURES

5.1 Potentiometric Surface Mapping

5.1.1 Selection of Wells

All wells used to prepare a flow net in a plan or map view should represent the same hydrogeologic unit, be it aquifer or aquitard. All water level measurements used shall be collected on the same day, preferably within 2-3 hours. This is especially important when working in an area where groundwater levels are tidally influenced or influenced by pumping.

The recorded water levels, monitoring-well construction data, site geology, and topographic setting must be reviewed to ascertain that the wells are completed in the same hydrogeologic unit and to determine if strong vertical hydraulic gradients may be present. Such conditions will be manifested by a pronounced correlation between well depth and water level, or by a difference in water level between two wells located near each other but set to different depths or having different screen lengths. Professional judgment of the hydrogeologist is important in this determination. If vertical gradients are significant, the data to be used must be limited vertically, and only wells finished in a chosen vertical zone of the hydrogeologic unit can be used.

At least three wells must be used to provide an estimation of the direction of groundwater flow; information from many more wells are needed to provide an accurate contour map. Generally, shallow systems require data from more wells than deep systems for accurate contour mapping. Potentiometric surface mapping for shallow flow systems also requires water level measurements from nearby surface water bodies.

5.1.2 Water Level Measurements

After selection of the wells to be used for mapping, the next step in determining the direction of groundwater flow is to obtain water level elevations from the selected points. In addition, any other readily available wells/surface water bodies should be measured to ensure that sufficient data are available for interpretation purposes.

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5	Page 4 of 9
	Revision 1	Effective Date 06/99

Elevations are obtained from measurements of the depth to water in a monitoring well or piezometer taken from the top of the well casing (see SOP GH-1.2) and then referencing the elevation of the casing to a chosen and consistent datum point, usually mean sea level. Subtracting the depth to water from the casing elevation provides the elevation of the potentiometric surface. Elevations of points and areas of groundwater discharge or recharge such as springs, seeps, streams, rivers, and lakes also need to be determined, typically through staff gauge measurements. Comparison of these elevations, which represent hydraulic heads, will reveal the direction of flow because groundwater flows from areas of high head to areas of low head.

5.1.3 Construction of Equipotential Lines

Graphical methods available for depicting the flow of groundwater include the use of equipotential lines and flow lines to construct potentiometric surface maps and vertical flow nets. If the hydrogeologic system consists of a water table aquifer and one or more confined aquifers, separate contour maps should be prepared for each aquifer system. Water table maps should be developed using water level measurements obtained from monitoring wells screened at the unsaturated-saturated interface. Water level measurements collected from monitoring wells screened in the deeper portions of an unconfined aquifer should generally be contoured as a separate potentiometric surface map. Surface water discharge or recharge features are contoured in the water table system. Vertical flow nets should be constructed using a cross section aligned parallel to the direction of groundwater flow. All water level measurements along this cross section, both deep and shallow, are used in developing equipotential lines and flow lines for the flow net.

To construct equipotential lines, water level elevations in the chosen wells are plotted on a site map. Other hydrogeologic features associated with the zone of interest – such as seeps, wetlands, and surface-water bodies – should also be plotted along with their elevations.

The data should then be contoured, using mathematically valid and generally accepted techniques. Linear interpolation is the most commonly used technique. However, quadratic interpolation or any technique of trend-surface analysis or data smoothing is acceptable. Computer-generated contour maps may be useful for rough mapping of large data sets; however, final, detailed mapping must always be performed by hand by an experienced hydrogeologist. Contour lines shall be drawn as smooth, continuous lines which never cross one another.

Inspect the contour map, noting known features, such as pumping wells and site topography. The contour lines must be adjusted utilizing the professional judgment of the hydrogeologist in accordance with these features. Closed contours should be avoided unless a known groundwater sink (i.e., pumping well) or mound exists. Groundwater mounding is common under landfills and lagoons; if the data imply this, the feature must be evident in the contour plot.

5.1.4 Determination of Groundwater-Flow Direction

Flow lines shall be drawn so that they are perpendicular to equipotential lines. Flow lines will begin at high head elevations and end at low head elevations. Closed highs will be the source of additional flow lines. Closed depressions (i.e., wells) will be the termination of some flow lines. Care must be used in areas with significant vertical gradients to avoid erroneous conclusions concerning gradients and flow directions.

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5	Page 5 of 9
	Revision 1	Effective Date 06/99

5.2 Groundwater Flow Considerations

Groundwater movement is an integral part of the hydrologic cycle. Recharge to the shallow groundwater environment generally occurs by infiltration of precipitation through an upper unsaturated soil zone. Movement is downward under the force of gravity until the water reaches the saturated zone of the water table aquifer. Once water is part of the water table aquifer, movement is controlled by differences in hydraulic head, with movement from areas of high head to areas of low head. Areas of low head include natural discharge areas such as springs, lakes, rivers, and, ultimately, the ocean. These features can be considered as outcrops of the water table. Points of low head also are created by pumping wells.

Local head differences and consequent vertical flow patterns within an aquifer can be detected by well clusters. A well cluster consists of several adjacent wells, generally installed within a few feet of each other, and screened at different depths. Variations in water levels in these closely spaced wells indicates the vertical component of groundwater flow within an aquifer, provided that the wells are all screened within the same aquifer.

The number, location, and extent of geologic units and their properties with regard to aquifer or aquitard characteristics must be understood to properly interpret water level data gathered from the monitoring system. This firm understanding of the hydrogeologic system must be developed through a program of borings, wells, and interpretation of subsurface geology. The adequacy of the positions and depths of borings/wells used to define relevant subsurface hydrogeologic conditions must also be assessed. The location of surface water discharge or recharge points must be considered. Surface water features influence the system, as flow is most likely toward them (if they are discharge points) or away from them (if they are recharge points). Man-made discharge or recharge features such as pumping or injection wells, ditches, and trenches can also affect the flow of groundwater.

5.3 Determination of Flow Rate

Darcy's Law states that the quantity of water flowing through a geologic material is dependent upon the permeability of the material, the hydraulic gradient, and the cross sectional area through which the water flows. This relation is expressed in the equation:

$$Q = KiA$$

where:

- Q = volume of water flowing through the cross sectional area of the formation (L^3/T).
- K = hydraulic conductivity (L/T).
- i = hydraulic gradient (L/L , i.e., dimensionless).
- A = cross sectional area of formation being considered (L^2).

The relation is similar to one used in stream flow measurements where:

$$Q = VA$$

where:

- Q = discharge from the cross sectional area of a stream or pipe (L^3/T).
- V = average velocity of flowing water (L/T).
- A = cross sectional area through which water flows (L^2).

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5	Page 6 of 9
	Revision 1	Effective Date 06/99

The velocity of water movement in a geologic formation depends on the specific formation properties and the head differences across the formation. This relation is defined in the equation:

$$V = \frac{Ki}{n}$$

where:

V = average linear velocity of groundwater through the formation (L/T)
K = hydraulic conductivity (L/T)
i = hydraulic gradient (dimensionless)
n = porosity (expressed as a fraction).

Values of porosity for several geologic materials are given in Attachment A. More accurate and specific values of porosity can be obtained by laboratory analysis of a formation sample or from an unconfined aquifer pumping test.

Hydraulic conductivity is related to the permeability of the formation and depends on the size and interconnection of the pore spaces. In isotropic and homogeneous formations, the hydraulic conductivity will be the same vertically and horizontally. In anisotropic formations, horizontal and vertical conductivity can be markedly different and the vertical hydraulic conductivity can be up to several orders of magnitude lower than the horizontal hydraulic conductivity. Typically, most formations are anisotropic with horizontal hydraulic conductivities at least several times as high as the vertical hydraulic conductivities.

Generally, hydraulic conductivities are high for sands, gravels, and limestone containing large solution cavities and low for silts, clays, and tightly fractured rock. Attachment A gives values of hydraulic conductivity for several geologic materials. More accurate values can be obtained during field testing of aquifers or from laboratory measurements on undisturbed cores. Results from field testing usually provide higher (and more representative) hydraulic conductivities than laboratory testing because full-scale field testing includes the effects of the formational macrostructure (i.e., secondary permeability due to jointing or fractures) which is not reflected in the testing of a small sample in the laboratory.

The hydraulic gradient, *i*, is determined from field measurements of hydraulic head obtained from water level measuring points. Do not measure gradient from well to well; measure across equipotential lines that are drawn based on the well (and other) data. Once a potentiometric surface map has been generated using the hydraulic head data, the hydraulic gradient can be calculated using the following formula:

$$i = \frac{dh}{dl}$$

where:

dh = change in head (L)
dl = distance between equipotential lines (L)

The hydraulic gradient along any flow line can be calculated from a potentiometric surface map by dividing the change in head by the length of the flow line, typically beginning and ending at equipotential lines. The longer the distance over which the head change is measured, the more representative the gradient is of overall conditions.

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5	Page 7 of 9
	Revision 1	Effective Date 06/99

When chemical solutes are traveling in groundwater, as in cases of groundwater contamination, the calculated groundwater velocity may predict migration rates in excess of what is actually observed. The difference in chemical versus water velocities may be due to attenuation or biodegradation of the chemical species in the aquifer. Attenuation is most often caused by adsorption of the chemical contaminant onto the formation grains or matrix. The result is that the chemical does not appear at the downgradient sampling point as quickly as the velocity calculation predicts. An equation to correct for this attenuation is:

$$V_c = V_w / (1 + K_d P_b / n)$$

where:

V_c	=	velocity of the chemical solute flow (L/T)
V_w	=	velocity of groundwater flow (L/T)
P_b	=	formation mass bulk density (M/L ³)
n	=	formation porosity (expressed as a fraction)
K_d	=	distribution coefficient = (L ³ /M)

The K_d is equal to the mass of solute per unit mass of solid phase divided by the concentration of solute in solution. The term in the denominator is known as the retardation factor.

Density and/or viscosity differences between water and contaminants can also cause velocity determination errors. Light hydrocarbons such as gasoline are less dense than water and consequently float on the water table. These contaminants can migrate along the water table surface at rates faster or slower than the rate of groundwater movement, depending on specific conditions, and may also volatilize into unsaturated soil pore spaces. Oils are more viscous than water and will typically migrate more slowly due to the viscosity difference. Contaminants denser than water such as heavy hydrocarbons (e.g., coal tar) or chlorinated compounds (e.g., TCE, PCE) tend to sink to the bottom of an aquifer if present in concentrations exceeding their solubility limit (these chemicals are often referred to as dense, nonaqueous phase liquids, or DNAPLs if present as a separate-phase liquid). Here, the contamination may move at faster or slower rates than the overlying groundwater or may actually move in a direction opposite to that of the groundwater, depending on the geologic characteristics of the aquifer base and direction of dip of the underlying aquitard.

Other factors involving the physicochemical interaction between the chemical and the groundwater, such as dilution (mixing contaminated water or chemicals with additional quantities of groundwater) and dispersion (molecular diffusion of the chemical throughout the groundwater regime), can also affect the observed rates of travel of contaminants in groundwater. In addition to such physicochemical characteristics, all of the aquifer and aquitard properties and groundwater flow characteristics described above must be known so that adequate and accurate estimations of the extent and rate of groundwater contaminant migration can be developed.

6.0 REFERENCES

- Cedergren, H. R., 1977. Seepage, Drainage and Flow Nets (Second edition). John Wiley and Sons, New York.
- Fetter, C. W., 1980. Applied Hydrogeology. Merrill, Columbus, Ohio, 488 pp.
- Davis, S. N. and R. J. DeWiest, 1966. Hydrogeology. John Wiley and Sons, New York.
- Freeze, R. A. and J. A. Cherry, 1979. Ground Water. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5	Page 8 of 9
	Revision 1	Effective Date 06/99

Johnson Division, UOP, Inc., 1975. Ground Water and Wells. Johnson Division, UOP, Inc., Saint Paul, Minnesota.

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5	Page 9 of 9
	Revision 1	Effective Date 06/99

ATTACHMENT A

GENERALIZED POROSITY AND HYDRAULIC CONDUCTIVITY VALUES FOR GEOLOGIC MATERIALS

Material	Porosity Range (%)	Hydraulic Conductivity Range	
		cm/sec	ft/day
Gravel	30-40	10^{-1} to 10^{-2}	280 to 2.8×10^5
Coarse sand (clean)	30-40	10^{-1} to 1	280 to 2,800
Medium sand (clean)	35-45	10^{-2} to 10^{-1}	28 to 280
Fine sand (clean)	40-50	5×10^{-4} to 10^{-2}	1.4 to 28
Silty sand	25-40	10^{-5} to 10^{-2}	0.03 to 280
Glacial Till	Variable	10^{-10} to 10^{-4}	3×10^{-7} to 0.3
Unweathered Clay/Shale	45-55 (clay)	10^{-7} to 10^{-4}	3×10^{-4} to 0.3 (horizontal)
		10^{-10} to 10^{-6}	3×10^{-7} to 3×10^{-3} (vertical)
Karst Limestone	—	10^{-4} to 10^{-1}	0.3 to 2,800
Fractured Igneous/Metamorphic Rocks	—	10^{-6} to 10^{-1}	3×10^{-3} to 280
Sandstone	5-30	10^{-8} to 10^{-4}	3×10^{-5} to 0.3

Source: References 1 and 2



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number	SA-1-1	Page	1 of 27
Effective Date	06/99	Revision	4
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>DS</i>		

Subject

GROUNDWATER SAMPLE ACQUISITION AND
ONSITE WATER QUALITY TESTING

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE	2
2.0 SCOPE	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES	2
5.0 PROCEDURES	3
5.1 GENERAL	3
5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT	4
5.3 CALCULATIONS OF WELL VOLUME	4
5.4 EVACUATION OF STATIC WATER (PURGING)	5
5.4.1 General	5
5.4.2 Evacuation Devices	5
5.5 ONSITE WATER QUALITY TESTING	7
5.5.1 Measurement of pH	7
5.5.2 Measurement of Specific Conductance	9
5.5.3 Measurement of Temperature	10
5.5.4 Measurement of Dissolved Oxygen	11
5.5.5 Measurement of Oxidation-Reduction Potential	13
5.5.6 Measurement of Turbidity	14
5.5.7 Measurement of Salinity	15
5.6 SAMPLING	16
5.6.1 Sampling Plan	16
5.6.2 Sampling Methods	17
5.7 LOW FLOW PURGING AND SAMPLING	18
5.7.1 Scope & Application	18
5.7.2 Equipment	18
5.7.3 Purging and Sampling Procedure	19
6.0 REFERENCES	20
<u>ATTACHMENTS</u>	
A PURGING EQUIPMENT SELECTION	22
B SPECIFIC CONDUCTANCE OF 1 MOLAR KCl AT VARIOUS TEMPERATURES	25
C VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY	26

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 2 of 27
	Revision 4	Effective Date 06/99

1.0 PURPOSE

The purpose of this procedure is to provide general reference information regarding the sampling of groundwater wells.

2.0 SCOPE

This procedure provides information on proper sampling equipment, onsite water quality testing, and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence, and relative concentrations, and on temperature of measure. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 mS/cm at 14C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Salinity – Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Note: most field meters determine salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

Turbidity – Turbidity in water is caused by suspended matter, such as clay, silt, fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES

Project Hydrogeologist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 3 of 27
	Revision 4	Effective Date 06/99

Project Geologist - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field technicians).

5.0 PROCEDURES

5.1 General

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended prior to sampling. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical.
2. For wells that can be purged dry, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is required.
3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:
 - A submersible pump or the intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level drops. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.
 - The intake line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a low purge rate, equal to the well's recovery rate (low flow sampling).

Stratification of contaminants may exist in the aquifer. Concentration gradients as a result of mixing and dispersion processes, layers of variable permeability, and the presence of separate-phase product (i.e.,

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 4 of 27
	Revision 4	Effective Date 06/99

floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column as it naturally occurs at that point, thus the result is the collection of a non-representative sample.

5.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with the guidelines expressed in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler, ice, labels and chain-of-custody documents.
- Field tools and instrumentation - Multi-parameters water quality meter capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity and salinity or individual meters (as applicable), pH paper, camera and film (if appropriate), appropriate keys (for locked wells), engineer's rule, water level indicator.
- Pumps
 - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.
 - Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.
- Other sampling equipment - Bailers and inert line with tripod-pulley assembly (if necessary).
- Pails - Plastic, graduated.
- Decontamination solutions - Deionized water, potable water, laboratory detergents, 10% nitric acid solution (as required), and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

5.3 Calculations of Well Volume

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form (see SOP SA-6.3):

- Obtain all available information on well construction (location, casing, screens, etc.).
- Determine well or casing diameter.
- Measure and record static water level (depth below ground level or top of casing reference point).

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 5 of 27
	Revision 4	Effective Date 06/99

- Determine depth of well by sounding using a clean, decontaminated, weighted tape measure.
- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
- Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$

where: V = Static volume of well in gallons.
T = Thickness of water table in the well measured in feet (i.e., linear feet of static water).
r = Inside radius of well casing in inches.
0.163 = A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

5.4 Evacuation of Static Water (Purging)

5.4.1 General

The amount of purging a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, specific conductance, pH, and turbidity (as applicable), have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook, field notebook, or on standardized data sheets.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 6 of 27
	Revision 4	Effective Date 06/99

- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics.

Air-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Air (or gas)-lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation, or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time-consuming.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 7 of 27
	Revision 4	Effective Date 06/99

5.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO)
- Oxidation Reduction Potential (ORP)
- Certain Dissolved Constituents Using Specific Ion Elements
- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, and colloidal material or suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use.

5.5.1 Measurement of pH

5.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

5.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific pH range hydron paper.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 8 of 27
	Revision 4	Effective Date 06/99

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

5.5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Stand-alone portable pH meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 610).
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs).
- Buffer solutions, as specified by the manufacturer.
- pH indicator paper, to cover the pH range 2 through 12.
- Manufacturer's operation manual.

5.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure is used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- Inspect the instrument and batteries prior to initiation of the field effort.
- Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
- If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
- Calibrate on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on an equipment calibration log sheet.
- Immerse the electrode(s) in the sample, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.
- Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH unit. Also record the sample temperature.
- Rinse the electrode(s) with deionized water.
- Store the electrode(s) in an appropriate manner when not in use.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 9 of 27
	Revision 4	Effective Date 06/99

Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is adequately determined.

5.5.2 Measurement of Specific Conductance

5.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

5.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 10 of 27
	Revision 4	Effective Date 06/99

5.5.2.3 Equipment

The following equipment is needed for taking specific conductance (SC) measurements:

- Stand alone portable conductivity meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 610).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available which may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirement of the sampling program.

5.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet. Potassium chloride solutions with a SC closest to the values expected in the field shall be used for calibration. Attachment B provides guidance in this regard.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature (if applicable).
- Read and record the results in a field logbook or sample log sheet.
- Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for details.

5.5.3 **Measurement of Temperature**

5.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled or dial-type thermometers. In addition, various meters such as specific conductance or dissolved oxygen meters, which have

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 11 of 27
	Revision 4	Effective Date 06/99

temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

5.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is used, the instrument shall be calibrated according to manufacturer's recommendations.

5.5.4 Measurement of Dissolved Oxygen

5.5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and is not susceptible to interference caused by color, turbidity, colloidal material or suspended matter.

5.5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH⁻) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, while leaving the surface of the solution undisturbed.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 12 of 27
	Revision 4	Effective Date 06/99

Dissolved oxygen probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide, which are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- Stand alone portable dissolved oxygen meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 610).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

5.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- The instrument shall be calibrated in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment C).
- Record all pertinent information on an equipment calibration sheet.
- Rinse the probe with deionized water.
- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells can be moved up and down.
- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.
- Rinse the probe with deionized water.
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 13 of 27
	Revision 4	Effective Date 06/99

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical. Be sure to record whether the liquid was analyzed in-situ, or if a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

5.5.5 Measurement of Oxidation-Reduction Potential

5.5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

5.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

5.5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- Check that the platinum probe is clean and that the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aqua regia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.
- Thoroughly rinse the electrode with deionized water.
- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases, and the ORP

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 14 of 27
	Revision 4	Effective Date 06/99

will decrease if the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added (i.e., pH is raised) thus indicating the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.

- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of deionized water from a wash bottle. Place the sample in a clean container and insert the electrodes. Set temperature compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook or sample logsheet, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

5.5.6 Measurement of Turbidity

5.5.6.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and microscopic organisms, including plankton.

It is important to obtain a turbidity reading immediately after taking a sample, since irreversible changes in turbidity may occur if the sample is stored too long.

5.5.6.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method. This method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTU) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

5.5.6.3 Equipment

The following equipment is needed for turbidity measurement:

- Stand alone portable turbidity meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 61).

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 15 of 27
	Revision 4	Effective Date 06/99

- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.6.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the probe in the sample and measure the turbidity. The reading must be taken immediately as suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
- Read and record the results in a field logbook or sample log sheet. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
- Rinse the electrode with deionized water.

5.5.7 Measurement of Salinity

5.5.7.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Note: Most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

5.5.7.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (found in *Standard methods for the Examination of Water and Wastewater*). Depending on the meter, the results are displayed in either ppt or %. The salinity measurements are carried out in reference to the conductivity of standard seawater (*corrected to S = 35*).

5.5.7.3 Equipment

The following equipment is needed for Salinity measurements:

- Multi-parameter water quality meter capable of measuring conductive, temperature and converting them to salinity (e.g., Horiba U-10 or YSI 610).
- Calibration Solution, as specified by the manufacturer.
- Manufacturer's operation manual.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 16 of 27
	Revision 4	Effective Date 06/99

5.5.7.4 Measurement Techniques for Salinity

The steps involved in taking Salinity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with the sample to be tested.
- Immerse the probes in the sample and measure the salinity. Read and record the results in a field logbook or sample log sheet.
- Rinse the probes with deionized water.

5.6 Sampling

5.6.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the project plan documents which are approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 17 of 27
	Revision 4	Effective Date 06/99

5.6.2 Sampling Methods

The collection of a groundwater sample consists of the following steps:

1. The site Health & Safety Officer (or designee) will first open the well cap and use volatile organic detection equipment (PID or FID) on the escaping gases at the well head to determine the need for respiratory protection.
2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet (see SOP SA-6.3); then calculate the fluid volume in the well pipe (as previously described in this SOP).
3. Calculate well volume to be removed as stated in Section 5.3.
4. Select the appropriate purging equipment (see Attachment A). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower the purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (as applicable). Lower the purging device, as required, to maintain submergence.
6. Measure the rate of discharge frequently. A graduated bucket and stopwatch are most commonly used; other techniques include use of pipe trajectory methods, weir boxes or flow meters.
7. Observe the peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.
8. Purge a minimum of three to five casing volumes before sampling. In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Purged water shall be collected in a designated container and disposed in an acceptable manner.
9. If sampling using a pump, lower the pump intake to midscreen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.
10. (For pump and packer assembly only). Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
11. In the event that recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook.
12. Fill sample containers (preserve and label as described in SOP SA-6.1).

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 18 of 27
	Revision 4	Effective Date 06/99

13. Replace the well cap and lock as appropriate. Make sure the well is readily identifiable as the source of the samples.
14. Process sample containers as described in SOP SA-6.1.
15. Decontaminate equipment as described in SOP SA-7.1.

5.7 Low Flow Purging and Sampling

5.7.1 Scope & Application

Low flow purging and sampling techniques are sometimes required for groundwater sampling activities. The purpose of low flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 2 inches or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect non-aqueous phase liquids samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs), using the low flow pumps.

The procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 5 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

5.7.2 Equipment

The following equipment is required (as applicable) for low flow purging and sampling:

- Adjustable rate, submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).
- Disposable clear plastic bottom filling bailers may be used to check for and obtain samples of LNAPLs or DNAPLs.
- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Flow measurement supplies.
- Interface probe, if needed.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 19 of 27
	Revision 4	Effective Date 06/99

- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments - pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional Indicators - ORP and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s), and other forms (e.g., well purging forms).
- Sample Bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event.
- Field Sampling Plan.
- PID or FID instrument for measuring VOCs (volatile organic compounds).

5.7.3 Purging and Sampling Procedure

Use a submersible pump to purge and sample monitoring wells which have a 2.0 inch or greater well casing diameter.

Measure and record the water level immediately prior to placing the pump in the well.

Lower pump, safety cable, tubing and electrical lines slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is three feet or less of standing water in the well.

When starting the pump, slowly increase the pump speed until a discharge occurs. Check water level. Adjust pump speed to maintain little or no water level drawdown. The target drawdown should be less than 0.3 feet and it should stabilize. If the target of less than 0.3 feet cannot be achieved or maintained, the sampling is acceptable if remaining criteria in the procedure are met. Subsequent sampling rounds will probably have intake settings and extraction rates that are comparable to those used in the initial sampling rounds.

Monitor water level and pumping rate every five to ten minutes (or as appropriate) during purging. Record pumping rate adjustments and depths to water. Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (e.g., 0.1-0.2 l/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During initial pump start-up, drawdown may exceed the 0.3 feet target and then recover as pump flow adjustments are made (minimum purge volume calculations should utilize stabilized drawdown values, not the initial drawdown). If the recharge rate of the well is less than minimum capability of the pump do not

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 20 of 27
	Revision 4	Effective Date 06/99

allow the water level to fall to the intake level (if the static water level is above the screen, avoid lowering the water level into the screen). Shut off the pump if either of the above is about to occur and allow the water level to recover. Repeat the process until field indicator parameters stabilize and the minimum purge volume is removed. The minimum purge volume with negligible drawdown (0.3 feet or less) is two saturated screen length volumes. In situations where the drawdown is greater than 0.3 feet and has stabilized, the minimum purge volume is two times the saturated screen volume plus the stabilized drawdown volume. After the minimum purge volume is attained (and field parameters have stabilized) begin sampling. For low yield wells, commence sampling as soon as the well has recovered sufficiently to collect the appropriate volume for all anticipated samples.

During well purging, monitor field indicator parameters (turbidity, temperature, specific conductance, pH, etc.) every five to ten minutes (or as appropriate). Purging is complete and sampling may begin when all field indicator parameters have stabilized (variations in values are within ten percent of each other, pH +/- 0.2 units, for three consecutive readings taken at five to ten minute intervals). If the parameters have stabilized, but turbidity remains above 5 NTU goal, decrease pump flow rate, and continue measurement of parameters every five to ten minutes. If pumping rate cannot be decreased any further and stabilized turbidity values remain above 5 NTU goal record this information. Measurements of field parameters should be obtained (as per Section 5.5) and recorded.

VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples: (1) Collect the non-VOCs samples first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample and record the new flow rate; (2) reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel), or clamp which should reduce the flow rate by constricting the end of the tubing; (3) insert a narrow diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, collect sample from the narrow diameter tubing.

Prepare samples for shipping as per SOP SA-6.1.

6.0 REFERENCES

American Public Health Association, 1989. Standard Methods for the Examination of Water and Wastewater, 17th Edition, APHA, Washington, D.C.

Barcelona, M. J., J. P. Gibb and R. A. Miller, 1983. A guide to the Selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

Johnson Division, UOP, Inc. 1975. Ground Water and Wells, A Reference Book for the Water Well Industry. Johnson Division, UOP, Inc., Saint Paul, Minnesota.

Nielsen, D. M. and G. L. Yeates, 1985. A Comparison of Sampling Mechanisms Available for Small-Diameter Ground Water Monitoring Wells. Ground Water Monitoring Review 5:83-98.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 21 of 27
	Revision 4	Effective Date 06/99

Scaff, M. R., J. F. McNabb, W. J. Dunlap, R. L. Crosby and J. Fryberger, 1981. Manual of Ground Water Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

U.S. EPA, 1980. Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities. Office of Solid Waste, United States Environmental Protection Agency, Washington, D.C.

U.S. EPA, 1994. Groundwater Sampling Procedure - Low Flow Purge and Sampling (Draft Final). U.S. Environmental Protection Agency, Region I.

U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

Subject

GROUNDWATER SAMPLE
ACQUISITION AND ONSITE
WATER QUALITY TESTING

Number

SA-1-1

Page

22 of 27

Revision

4

Effective Date

06/99

ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet		X	X	X	X			
	Water Level >25 feet				X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

ATTACHMENT A PURGING EQUIPMENT SELECTION

PAGE 2

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	\$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	\$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	\$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	\$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	\$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	\$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	\$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Delrin®, acetal	0-150	0-7,500 mL/min	\$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	\$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	\$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Delrin®	No limit	Approximately 250 mL	\$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/38	PVC	0-230	0-2,000 mL/min	\$300-400	Requires compressed gas; piezometric level indicator; other materials available.

Subject
GROUNDWATER SAMPLE
ACQUISITION AND ONSITE
WATER QUALITY TESTING

Number,
SA-1-1
Revision
4

Page
23 of 27
Effective Date
06/99

ATTACHMENT A
PURGING EQUIPMENT SELECTION
PAGE 3

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/L length (inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	\$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	\$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	\$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	\$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailor	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailor	\$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	\$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	\$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

PE Polyethylene
 PP Polypropylene
 PVC Polyvinyl chloride
 SS Stainless steel
 PC Polycarbonate
 EPDM Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

AC Alternating current
 DC Direct current
 NA Not applicable

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

Subject
 GROUNDWATER SAMPLE
 ACQUISITION AND ONSITE
 WATER QUALITY TESTING

Number
 SA-1-1
Revision
 4

Page
 24 of 27
Effective Date
 06/99

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 25 of 27
	Revision 4	Effective Date 06/99

ATTACHMENT B

SPECIFIC CONDUCTANCE OF 1 MOLAR KCl AT VARIOUS TEMPERATURES¹

Temperature (°C)	Specific Conductance (umhos/cm)
15	1,147
16	1,173
17	1,199
18	1,225
19	1,251
20	1,278
21	1,305
22	1,332
23	1,359
24	1,368
25	1,413
26	1,441
27	1,468
28	1,496
29	1,524
30	1,552

¹ Data derived from the International Critical
Tables 1-3-8.

Subject	GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number	SA-1-1	Page	26 of 27
		Revision	4	Effective Date	06/99

ATTACHMENT C

VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

Temperature (°C)	Dissolved Oxygen (mg/L)					
	Chloride Concentration in Water					Difference/ 100 mg Chloride
	0	5,000	10,000	15,000	20,000	
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.016
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008
25	8.4	8.0	7.6	7.2	6.7	0.008

Subject

GROUNDWATER SAMPLE
ACQUISITION AND ONSITE
WATER QUALITY TESTING

Number

SA-1-1

Page

27 of 27

Revision

4

Effective Date

06/99

ATTACHMENT C
VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER
AS A FUNCTION OF TEMPERATURE AND SALINITY
PAGE TWO

Temperature (°C)	Dissolved Oxygen (mg/L)						Difference/ 100 mg Chloride
	Chloride Concentration in Water						
	0	5,000	10,000	15,000	20,000		
26	8.2	7.8	7.4	7.0	6.6	0.008	
27	8.1	7.7	7.3	6.9	6.5	0.008	
28	7.9	7.5	7.1	6.8	6.4	0.008	
29	7.8	7.4	7.0	6.6	6.3	0.008	
30	7.6	7.3	6.9	6.5	6.1	0.008	
31	7.5						
32	7.4						
33	7.3						
34	7.2						
35	7.1						
36	7.0						
37	6.9						
38	6.8						
39	6.7						
40	6.6						
41	6.5						
42	6.4						
43	6.3						
44	6.2						
45	6.1						
46	6.0						
47	5.9						
48	5.8						
49	5.7						
50	5.6						

Note: In a chloride solution, conductivity can be roughly related to chloride concentration (and therefore, used to correct measured D.O. concentration) using Attachment B.



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number

SA-2.5

Page

1 of 6

Effective Date

09/03

Revision

3

Applicability

Tetra Tech NUS, Inc.

Prepared

Earth Sciences Department

Subject DIRECT PUSH TECHNOLOGY
(GEOPROBE®/HYDROPUNCH™)

Approved

D. Senovich

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE	2
2.0 SCOPE	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES	2
5.0 SOIL SAMPLING PROCEDURES	3
5.1 GENERAL	3
5.2 SAMPLING EQUIPMENT	3
5.3 DPT SAMPLING METHODOLOGY	3
6.0 GROUNDWATER SAMPLING PROCEDURES	4
6.1 GENERAL	4
6.2 SAMPLING EQUIPMENT	4
6.3 DPT TEMPORARY WELL POINT INSTALLATION AND SAMPLING METHODOLOGY	5
7.0 RECORDS	5
 <u>ATTACHMENTS</u>	
1 SAFE WORK PERMIT	6

Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)	Number SA-2.5	Page 2 of 6
	Revision 3	Effective Date 09/03

1.0 PURPOSE

The purpose of this procedure is to provide general reference information on Direct Push Technology (DPT). DPT is designed to collect soil, groundwater, and soil gas samples without using conventional drilling techniques. The advantage of using DPT over conventional drilling includes the generation of little or no drill cuttings, sampling in locations with difficult accessibility, reduced overhead clearance requirements, no fluid introduction during probing, and typical lower costs per sample than with conventional techniques. Disadvantages include a maximum penetration depth of approximately 15 to 40 feet in dense soils (although it may be as much as 60 to 80 feet in certain types of geological environments), reduced capability of obtaining accurate water-level measurements, and the inability to install permanent groundwater monitoring wells. The methods and equipment described herein are for collection of surface and subsurface soil samples and groundwater samples. Soil gas sampling is discussed in SOP SA-2.4.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for DPT. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

Direct Push Technology (DPT) - DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. A primary advantage of DPT over conventional drilling techniques is that DPT results in the generation of little or no investigation derived waste.

Geoprobe® - Geoprobe® is a manufacturer of a hydraulically-powered, percussion/probing machines utilizing DPT to collect subsurface environmental samples. Geoprobe® relies on a relatively small amount of static weight (vehicle) combined with percussion as the energy for advancement of a tool string. The Geoprobe® equipment can be mounted in a multitude of vehicles for access to all types of environmental sites.

HydroPunch™ - HydroPunch™ is a manufacturer of stainless steel and Teflon® sampling tools that are capable of collecting representative groundwater and/or soil samples without requiring the installation of a groundwater monitoring well or conventional soil boring. HydroPunch™ is an example of DPT sampling equipment.

Flame Ionization Detector (FID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing a flame as the energizing source.

Photo Ionization Detector (PID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing ultraviolet radiation as the energizing source.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for selecting and/or reviewing the appropriate DPT drilling procedure required to support the project objectives.

Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)	Number SA-2.5	Page 3 of 6
	Revision 3	Effective Date 09/03

Field Operations Leader (FOL)– The FOL is primarily responsible for performing the DPT in accordance with the project-specific plan.

5.0 SOIL SAMPLING PROCEDURES

5.1 General

The common methodology for the investigation of the vadose zone is soil boring drilling and soil sampling. However, drilling soil borings can be very expensive. Generally the advantage of DPT for subsurface soil sampling is the reduced cost of disposal of drilling cuttings and shorter sampling times.

5.2 Sampling Equipment

Equipment needed for conducting DPT drilling for subsurface soil sampling includes, but is not limited to, the following:

- Geoprobe® Sampling Kit
- Cut-resistant gloves
- 4-foot x 1.5-inch diameter macrocore sampler
- Probe sampling adapters
- Roto-hammer with 1.5-inch bit
- Disposable acetate liners for soil macrocore sampler
- Cast aluminum or steel drive points
- Geoprobe® AT-660 Series Large Bore Soil Sampler, or equivalent
- Standard decontamination equipment and solutions

For health and safety equipment and procedures, follow the direction provided in the Safe Work Permit in Attachment 1, or the more detailed directions provided in the project's Health and Safety Plan.

5.3 DPT Sampling Methodology

There are several methods for the collection of soil samples using DPT drilling. The most common method is discussed in the following section. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project-specific plan.

- Macrocore samplers fitted with detachable aluminum or steel drive points are driven into the ground using hydraulic pressure. If there is concrete or pavement over a sampling location, a Roto-hammer is used to drill a minimum 1.5-inch diameter hole through the surface material. A Roto-hammer may also be used if very dense soils are encountered.
- The sampler is advanced continuously in 4-foot intervals or less if desired. No soil cuttings are generated because the soil which is not collected in the sampler is displaced within the formation.
- The sampler is retracted from the hole, and the 4-foot continuous sample is removed from the outer coning tube. The sample is contained within an inner acetate liner.
- Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tail gate is not available, secure the trough on another suitable surface.
- Place the acetate liner containing the soils in the trough.

Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)	Number SA-2.5 Revision 3	Page 4 of 6 Effective Date 09/03
<ul style="list-style-type: none"> • While wearing cut-resistant gloves (constructed of leather or other suitable material), cut the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. Do <u>not</u> attempt to cut the acetate liner while holding it in your hand. • Field screen the sample with an FID or PID, and observe/examine the sample (according to SOP GH-1.3). If appropriate, transfer the sample to sample bottles for laboratory analysis. If additional volume is required, push an additional boring adjacent to the first and composite/mix the same interval. Field compositing is usually not acceptable for sample requiring volatile organics analysis. • Once sampling has been completed, the hole is backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch is used to cap holes through paved or concrete areas. All holes should be finished smooth to existing grade. • In the event the direct push van/truck cannot be driven to a remote location or a sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric operated equipment (e.g., jack hammer). • Sampling equipment is decontaminated prior to collecting the next sample. 		
6.0 GROUNDWATER SAMPLING PROCEDURES		
6.1 General		
<p>The most common methodology for the investigation of groundwater is the installation and sampling of permanent monitoring wells. If only groundwater screening is required, the installation and sampling of temporary well points may be performed. The advantage of temporary well point installation using DPT is reduced cost due to no or minimal disposal of drilling cuttings and well construction materials, and shorter installation/times sampling.</p>		
<p>Two disadvantages of DPT drilling for well point installation are:</p>		
<ul style="list-style-type: none"> • In aquifers with low yields, well points may have to be sampled without purging or development. • If volume requirements are high, this method can be time consuming for low yield aquifers. 		
6.2 Sampling Equipment		
<p>Equipment needed for temporary well installation and sampling using DPT includes, but is not limited, to the following:</p>		
<ul style="list-style-type: none"> • 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point • Connecting rods • Roto-hammer with 1.5-inch bit • Mechanical jack • 1/4-inch OD polyethylene tubing • 3/8-inch OD polyethylene tubing • Peristaltic pump • Standard decontamination equipment and solutions 		

Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)	Number SA-2.5	Page 5 of 6
	Revision 3	Effective Date 09/03

6.3 DPT Temporary Well Point Installation and Sampling Methodology

There are several methods for the installation and sampling of temporary well points using DPT. The most common methodology is discussed below. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project specific plan.

- A 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point attached to connecting rods is driven into the ground to the desired depth using a rotary electric hammer or other direct push drill rig. If there is concrete or pavement over a sampling location, a Roto-hammer or electric coring machine is used to drill a hole through the surface material.
- The well point will be allowed to equilibrate for at least 15 minutes, after which a measurement of the static water level will be taken. The initial measurement of the water level will be used to assess the amount of water which is present in the well point and to determine the amount of silt and sand infiltration that may have occurred.
- The well point will be developed using a peristaltic pump and polyethylene tubing to remove silt and sand which may have entered the well point. The well point is developed by inserting polyethylene tubing to the bottom of the well point and lifting and lowering the tubing slightly while the pump is operating. The pump will be operated at a maximum rate of approximately 2 liters per minute. After removal of sediment from the bottom of the well point, the well point will be vigorously pumped at maximum capacity until discharge water is visibly clear and no further sediments are being generated. Measurements of pH, specific conductance, temperature, and turbidity shall be recorded every 5 to 10 minutes during the purging process. After two consistent readings of pH, specific conductance, temperature and turbidity (± 10 percent), the well may be sampled.
- A sample will be collected using the peristaltic pump set at the same or reduced speed as during well development. Samples (with the exception of the samples to be analyzed for volatile organic compounds, VOCs) will be collected directly from the pump discharge. Sample containers for VOCs will be filled by (first shutting off the pump) crimping the discharge end of the sample tubing when filled, removing the inlet end of the sample tubing from the well, suspending the inlet tubing above the vial, and allowing water to fill each vial by gravity flow.
- Once the groundwater sample has been collected, the connecting rods and well point will be removed from the hole with the direct push rig hydraulics. The hole will be backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch will be used to cap holes through paved or concrete areas. All holes will be finished smooth to existing grade.
- In the event the direct push van/truck cannot be driven to a remote location or sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric-operated equipment (e.g., jack hammer).
- Decontaminate the equipment before moving to the next location.

7.0 RECORDS

A record of all field procedures, tests, and observations must be recorded in the field logbook, boring logs, and sample log sheets, as needed. Entries should include all pertinent data regarding the investigation. The use of sketches and field landmarks will help to supplement the investigation and evaluation.

Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)	Number SA-2.5	Page 6 of 6
	Revision 3	Effective Date 09/03

ATTACHMENT 1
SAFE WORK PERMIT FOR DPT OPERATIONS

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Monitoring well drilling and installation through direct push technology

II. Required Monitoring Instruments: _____

III. Field Crew: _____

IV. On-site inspection conducted ☐ Yes ☐ No Initials of Inspector TINUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

V. Protective equipment required

Level D <input checked="" type="checkbox"/> Level B <input type="checkbox"/>	Respiratory equipment required	Escape Pack <input type="checkbox"/>
Level C <input type="checkbox"/> Level A <input type="checkbox"/>	Full face APR <input type="checkbox"/>	SCBA <input type="checkbox"/>
Detailed on Reverse	Half face APR <input type="checkbox"/>	Bottle Trailer <input type="checkbox"/>
	SKA-PAC SAR <input type="checkbox"/>	None <input checked="" type="checkbox"/>
	Skid Rig <input type="checkbox"/>	

Level D Minimum Requirements: Sleeved shirt and long pants, safety footwear, and work gloves. Safety glasses, hard hats, and hearing protection will be worn when working near or sampling in the vicinity of the DPT rig.

Modifications/Exceptions:

VI. Chemicals of Concern	Action Level(s)	Response Measures

VII. Additional Safety Equipment/Procedures

Hard-hat <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Hearing Protection (Plugs/Muffs) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Safety Glasses <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Safety belt/harness <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
Chemical/splash goggles <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Radio <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
Splash Shield <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Barricades <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Splash suits/coveralls <input type="checkbox"/> Yes <input type="checkbox"/> No	Gloves (Type - _____) <input type="checkbox"/> Yes <input type="checkbox"/> No
Steel toe Work shoes or boots <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Work/warning regimen <input type="checkbox"/> Yes <input type="checkbox"/> No

Modifications/Exceptions: Reflective vests for high traffic areas.

VIII. Procedure review with permit acceptors

Yes	NA	Yes	NA
Safety shower/eyewash (Location & Use) <input type="checkbox"/> Yes <input checked="" type="checkbox"/> NA	Emergency alarms <input type="checkbox"/> Yes <input type="checkbox"/> NA		
Daily tail gate meetings <input checked="" type="checkbox"/> Yes <input type="checkbox"/> NA	Evacuation routes <input type="checkbox"/> Yes <input type="checkbox"/> NA		
Contractor tools/equipment/PPE inspected <input type="checkbox"/> Yes <input type="checkbox"/> NA	Assembly points <input type="checkbox"/> Yes <input type="checkbox"/> NA		

IX. Site Preparation

Utility Clearances obtained for areas of subsurface investigation <input type="checkbox"/> Yes <input type="checkbox"/> No
Physical hazards removed or blockaded <input type="checkbox"/> Yes <input type="checkbox"/> No
Site control boundaries demarcated/signage <input type="checkbox"/> Yes <input type="checkbox"/> No

X. Equipment Preparation

Yes	NA
Equipment drained/depressurized <input type="checkbox"/> Yes <input checked="" type="checkbox"/> NA	
Equipment purged/cleaned <input type="checkbox"/> Yes <input checked="" type="checkbox"/> NA	
Isolation checklist completed <input type="checkbox"/> Yes <input checked="" type="checkbox"/> NA	
Electrical lockout required/field switch tested <input type="checkbox"/> Yes <input checked="" type="checkbox"/> NA	
Blinds/misalignments/blocks & bleeds in place <input type="checkbox"/> Yes <input checked="" type="checkbox"/> NA	
Hazardous materials on walls/behind liners considered <input type="checkbox"/> Yes <input checked="" type="checkbox"/> NA	

XI. Additional Permits required (Hot work, confined space entry) ☐ Yes ☐ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

XII. Special instructions, precautions:

Permit Issued by: _____ Permit Accepted by: _____



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number

SA-6.1

Page

1 of 11

Effective Date

02/04

Revision

3

Applicability

Tetra Tech NUS, Inc.

Prepared

Earth Sciences Department

Subject

NON-RADIOLOGICAL SAMPLE HANDLING

Approved

D. Senovich

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE.....	2
2.0 SCOPE.....	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES.....	3
5.0 PROCEDURES.....	3
5.1 SAMPLE CONTAINERS.....	3
5.2 SAMPLE PRESERVATION.....	3
5.2.1 Overview	4
5.2.2 Preparation and Addition of Reagents	4
5.3 FIELD FILTRATION	5
5.4 SAMPLE PACKAGING AND SHIPPING.....	6
5.4.1 Environmental Samples	6
6.0 REFERENCES.....	7
 <u>ATTACHMENTS</u>	
A GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS.....	8
B ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES	9

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 2 of 11
	Revision 3	Effective Date 02/04

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

2.0 SCOPE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.

3.0 GLOSSARY

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, IATA has adopted DOT "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (y261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (y261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s. - Not otherwise specified.

Packaging - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H₂SO₄
- Nitric Acid - HNO₃
- Sodium Hydroxide - NaOH

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 3 of 11
	Revision 3	Effective Date 02/04

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - $\text{Na}_2\text{S}_2\text{O}_3$

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

4.0 RESPONSIBILITIES

Field Operations Leader - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

5.1 Sample Containers

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

5.2 Sample Preservation

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 4 of 11
	Revision 3	Effective Date 02/04

changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to 4°C. Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO₃, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

The FOL is responsible for ensuring that an accurate Chemical Inventory is created and maintained for all hazardous chemicals brought to the work site (see Section 5 of the TtNUS Health and Safety Guidance Manual). Furthermore, the FOL must ensure that a corresponding Material Safety Data Sheet (MSDS) is collected for every substance entered on the site Chemical Inventory, and that all persons using/handling/ disposing of these substances review the appropriate MSDS for substances they will work with. The Chemical Inventory and the MSDSs must be maintained at each work site in a location and manner where they are readily-accessible to all personnel.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H ₂ SO ₄)	1 part concentrated H ₂ SO ₄ : 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO ₃)	Undiluted concentrated HNO ₃	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 5 of 11
	Revision 3	Effective Date 02/04

- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.
- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).
- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

Continue with proper base preservation of the sample as described above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

The sample pH is then raised to 9 using the NaOH preservative.

- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

5.3 Field Filtration

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 6 of 11
	Revision 3	Effective Date 02/04

- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter and discard prior to sample collection.
- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

5.4 Sample Packaging and Shipping

Only employees who have successfully completed the TtNUS "Shipping Hazardous Materials" training course are authorized to package and ship hazardous substances. These trained individuals are responsible for performing shipping duties in accordance with this training.

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)
- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.
- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.
- Pack with enough cushioning materials such as bubble wrap (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.
- If cooling is required (see Attachments A and B), place ice around sample container shoulders, and on top of packing material (minimum of 8 pounds of ice for a medium-size cooler).
- Seal (i.e., tape or tie top in knot) large liner bag.
- The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing the vials for VOC analysis. The COC form should then state how many coolers are included with that shipment.
- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 7 of 11
	Revision 3	Effective Date 02/04

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). Dangerous Goods Regulations, Montreal, Quebec, Canada.

U.S. Department of Transportation (latest issue). Hazardous Materials Regulations, 49 CFR 171-177.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, U.S. EPA-EMSL, Cincinnati, Ohio.

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 8 of 11
	Revision 3	Effective Date 02/04

ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration	Container ⁽¹⁾	Sample Size	Preservation ⁽²⁾	Holding Time ⁽²⁾
-------------------------------	--------------------------	-------------	-----------------------------	-----------------------------

WATER

Organics (GC&GC/MS)	VOC	Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days ⁽⁹⁾
	Extractables SVOCs and pesticide/PCBs)	(Low	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticide/PCBs)	(Medium	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals	Low	High-density polyethylene	1 L	HNO ₃ to pH ≤ 2	6 months (Hg-28 days)
		Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide	Low	High-density polyethylene	1 L	NaOH to pH > 12	14 days
	Cyanide	Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	14 days

SOIL

Organics (GC&GC/MS)	VOC		EnCore Sampler	(3) 5 g Samplers	Cool to 4°C	48 hours to lab preservation
	Extractables SVOCs and pesticides/PCBs)	(Low	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticides/PCBs)	(Medium	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium		Wide-mouth glass	8 oz.	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorga nic	High Hazard		Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All		Wide-mouth glass	4 oz.	None	35 days until extraction; 40 days after extraction
TCLP	All		Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction

AIR

Volatile Organics	Low/Medium	Charcoal tube -- 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended
----------------------	------------	---	-----------	-------------	--------------------

- 1 All glass containers should have Teflon cap liners or septa.
- 2 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 9 of 11
	Revision 3	Effective Date 02/04

ATTACHMENT B

ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
INORGANIC TESTS:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia - Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4°C; NaOH to pH 12; 0.6 g ascorbic acid ⁽⁵⁾	14 days ⁽⁶⁾
Fluoride	P	None required	28 days
Hardness	P, G	HNO ₃ to pH 2; H ₂ SO ₄ to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H ₂ SO ₄ to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Residue, Total	P, G	Cool, 4°C	7 days
Residue, Filterable (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 10 of 11
	Revision 3	Effective Date 02/04

**ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES
PAGE TWO**

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
-----------------------	--------------------------	--------------------------------	-------------------------------------

INORGANIC TESTS (Cont'd):

Sulfide	P, G	Cool, 4°C; add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours

METALS:⁽⁷⁾

Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours
Mercury (Hg)	P, G	HNO ₃ to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO ₃ to pH 2	6 months

ORGANIC TESTS:⁽⁸⁾

Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ HCl to pH 2 ⁽⁹⁾	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ adjust pH to 4-5 ⁽¹⁰⁾	14 days
Phenols ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
Benzidines ^{(11),(12)}	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction ⁽¹³⁾
Phthalate esters ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines ^{(11),(14)}	G, Teflon-lined cap	Cool, 4°C; store in dark; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
PCBs ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitroaromatics & Isophorone ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ ; store in dark	7 days until extraction; 40 days after extraction
Polynuclear Aromatic Hydrocarbons (PAHs) ^{(11),(14)}	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ ; store in dark	7 days until extraction; 40 days after extraction
Haloethers ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF) ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 11 of 11
	Revision 3	Effective Date 02/04

**ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES
PAGE THREE**

- (1) Polyethylene (P): generally 500 ml or Glass (G): generally 1L.
- (2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.
- (3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).
- (4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator.
- (5) Should only be used in the presence of residual chlorine.
- (6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
- (7) Samples should be filtered immediately on site before adding preservative for dissolved metals.
- (8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.
- (9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling.
- (10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
- (11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).
- (12) If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.
- (13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
- (14) For the analysis of diphenylnitrosamine, add 0.008% Na₂S₂O₃ and adjust pH to 7-10 with NaOH within 24 hours of sampling.
- (15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% Na₂S₂O₃.



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number	SA-6.3	Page	1 of 12
Effective Date	09/03	Revision	2
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>DS</i>		

Subject
FIELD DOCUMENTATION

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE.....	2
2.0 SCOPE.....	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES	2
5.0 PROCEDURES	2
5.1 SITE LOGBOOK	2
5.1.1 General.....	2
5.1.2 Photographs	3
5.2 FIELD NOTEBOOKS	3
5.3 FIELD FORMS	4
5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results..	4
5.3.2 Hydrogeological and Geotechnical Forms	5
5.3.3 Equipment Calibration and Maintenance Form	6
5.4 FIELD REPORTS.....	6
5.4.1 Daily Activities Report.....	6
5.4.2 Weekly Status Reports.....	7
6.0 LISTING OF TETRA TECH NUS FIELD FORMS FOUND ON THE TTNUS INTRANET SITE. HTTP://INTRANET.TTNUS.COM CLICK ON FIELD LOG SHEETS.....	7

ATTACHMENTS

A	TYPICAL SITE LOGBOOK ENTRY	9
B	SAMPLE LABEL.....	10
C	CHAIN-OF-CUSTODY RECORD FORM.....	11
D	CHAIN-OF-CUSTODY SEAL	12

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 2 of 12
	Revision 2	Effective Date 09/03

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Tetra Tech NUS field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Tetra Tech NUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Project Manager (PM) - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded or referenced (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Time and date of H&S training
- Arrival/departure of equipment
- Time and date of equipment calibration
- Start and/or completion of borehole, trench, monitoring well installation, etc.
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 3 of 12
	Revision 2	Effective Date 09/03

that onsite activities take place which involve Tetra Tech NUS or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Tetra Tech NUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the field notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strik mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook/notebook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided, since they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend upon the subject matter, type of camera (digital or film), and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Once processed, the slides of photographic prints shall be consecutively numb red and labeled according to the logbook/notebook descriptions. The site photographs and associated negatives and/or digitally saved images to compact disks must be docketed into the project's central file.

5.2 Field Notebooks

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 4 of 12
	Revision 2	Effective Date 09/03

5.3 Field Forms

All Tetra Tech NUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (<http://intranet.ttnus.com>) under Field Log Sheets. Forms may be altered or revised for project-specific needs contingent upon client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source electronically generated in-house, or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager (or designee), while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing vials for VOC analysis or the cooler with the air bill attached. The air bill should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment C. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Tetra Tech NUS Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The Custody seal is an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. The COC seals are signed and dated by the sampler(s) and affixed across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 5 of 12
	Revision 2	Effective Date 09/03

5.3.1.5 Geochemical Parameters Log Sheets

Field Analytical Log Sheets are used to record geochemical and/or natural attenuation field test results.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

A Groundwater Level Measurement Sheet must be filled out for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The Pumping Test Data Sheet facilitates this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be laid out in advance.

5.3.2.3 Packer Test Report Form

A Packer Test Report Form must be completed for each well upon which a packer test is conducted.

5.3.2.4 Boring Log

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring, or Boring Log is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a PID or FID), these readings must be entered on the boring log at the appropriate depth. The "Remarks" column can be used to subsequently enter the laboratory sample number, the concentration of key analytical results, or other pertinent information. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 6 of 12
	Revision 2	Effective Date 09/03

5.3.2.7 Miscellaneous Monitoring Well Forms

Monitoring Well Materials Certificate of Conformance should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record should be used as the project directs to document all well development activities.

5.3.2.8 Miscellaneous Field Forms - QA and Checklists

Container Sample and Inspection Sheet should be used as the project directs each time a container (drum, tank, etc.) is sampled and/or inspected.

QA Sample Log Sheet should be used at the project directs each time a QA sample is collected, such as Rinsate Blank, Source Blank, etc.

Field Task Modification Request (FTMR) will be prepared for all deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Copies of all FTMRs will be maintained with the onsite planning documents and originals will be placed in the final evidence file.

The Field Project Daily Activities Check List and Field Project Pre-Mobilization Checklist should be used during both the planning and field effort to assure that all necessary tasks are planned for and completed. These two forms are not a requirement but a useful tool for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure th proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used or in accordance with the manufacturer's recommendations.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 7 of 12
	Revision 2	Effective Date 09/03

5.4.1.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to summaries described herein, other summary reports may also be contractually required.

All Tetra Tech NUS field forms can be found on the company's intranet site at <http://intranet.ttnus.com> under Field Log Sheets.

6.0 LISTING OF TETRA TECH NUS FIELD FORMS FOUND ON THE TTNUS INTRANET SITE. [HTTP://INTRANET.TTNUS.COM](http://intranet.ttnus.com) CLICK ON FIELD LOG SHEETS

Groundwater Sample Log Sheet
Surface Water Sample Log Sheet
Soil/Sediment Sample Log Sheet
Container Sample and Inspection Sheet
Geochemical Parameters (Natural Attenuation)
Groundwater Level Measurement Sheet
Pumping Test Data Sheet
Packer Test Report Form
Boring Log
Monitoring Well Construction Bedrock Flush Mount
Monitoring Well Construction Bedrock Open Hole
Monitoring Well Construction Bedrock Stick Up
Monitoring Well Construction Confining Layer
Monitoring Well Construction Overburden Flush Mount
Monitoring Well Construction Overburden Stick Up
Test Pit Log
Monitoring Well Materials Certificate of Conformance
Monitoring Well Development Record

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 8 of 12
	Revision 2	Effective Date 09/03

Daily Activities Record
 Field Task Modification Request
 Hydraulic Conductivity Test Data Sheet
 Low Flow Purge Data Sheet
 QA Sample Log Sheet
 Equipment Calibration Log
 Field Project Daily Activities Checklist
 Field Project Pre-Mobilization Checklist

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 9 of 12
	Revision 2	Effective Date 09/03

**ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY**

START TIME: _____ DATE: _____

SITE LEADER: _____
PERSONNEL: _____

TtNUS

DRILLER

SITE VISITORS

WEATHER: Clear, 68°F, 2-5 mph wind from SE


ACTIVITIES:

1. Steam jenny and fire hoses were set up.
2. Drilling activities at well _____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page _____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit _____ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

Field Operations Leader

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 10 of 12
	Revision 2	Effective Date 09/03

ATTACHMENT B

 Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090		Project: Site: Location:	
Sample No:			Matrix:
Date:	Time:	Preserve:	
Analysis:			
Sampled by:		Laboratory:	



CHAIN OF CUSTODY

NUMBER 3413

PAGE OF

[illegible]

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE)

YELLOW (FIELD COPY)

PINK (FILE COPY):

4/02R
FORM NO. T1NUS-001

ATTACHMENT C

Subject

FIELD DOCUMENTATION

Number	SA-6.3
Revision	2

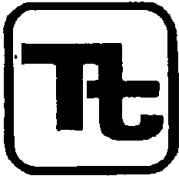
Page 11 of 12

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 12 of 12
	Revision 2	Effective Date 09/03

ATTACHMENT D

CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL		CUSTODY SEAL
Date		Date
Signature		Signature



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number	ME-15	Page	1 of 20
Effective Date	06/99	Revision	1
Applicability	Tetra Tech NUS, Inc.		
Prepared	Health Sciences Department		
Approved	D. Senovich <i>[Signature]</i>		

Subject PHOTOVAC MICROFID HANDHELD
FLAME IONIZATION DETECTOR

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE	2
2.0 SCOPE	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES	2
5.0 PROCEDURES	3
5.1 GENERAL	3
5.2 USE AND DOCUMENTATION OF RESULTS	3
5.3 PRINCIPLES OF OPERATION	3
5.4 CALIBRATION	10
5.5 ROUTINE MAINTENANCE	11
5.5.1 Battery Charging	11
5.5.2 Emptying the Hydrogen Cylinder	12
5.5.3 Replacing the Sample Inlet Filter	12
5.6 TROUBLESHOOTING	13
5.6.1 MicroFID Fault Messages	13
5.7 TRANSPORTING MICROFID	18
6.0 SHIPPING	18
7.0 REFERENCES	18

FIGURES

<u>NUMBER</u>	<u>PAGE</u>
5-1 DOCUMENTATION OF FIELD CALIBRATION	4
5-2 DIRECT-READING INSTRUMENT RESPONSE DATA	5
5-3 BORING LOG	7
5-4 TEST PIT LOG	8
6-1 EXAMPLE OF A HAZARDOUS AIRBILL FOR HYDROGEN	19
6-2 EXAMPLE OF A HAZARDOUS AIRBILL FOR METHANE IN AIR	20

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 2 of 20
	Revision 1	Effective Date 06/99

1.0 PURPOSE

To establish procedures for the use, calibration, maintenance, troubleshooting, and shipment of the Photovac MicroFID handheld flame ionization detector.

2.0 SCOPE

Applies to all Brown & Root Environmental personnel who operate the MicroFID instrument during the performance of their work.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Office Managers - Office Managers are responsible for ensuring that personnel under their direction who may use this device are first provided with adequate training and information.

Project Managers - Project Managers are responsible for ensuring that appropriate health and safety requirements and resources are addressed for their assigned projects.

Health and Safety Manager (HSM) - The HSM shall ensure that appropriate training is available to users of the Photovac MicroFID instrument.

Equipment Manager - The Equipment Manager shall ensure that all air monitoring instrumentation slated for field activities has been operationally checked out, fully charged, and calibrated prior to issuance for field service. Maintenance deficiencies identified by the Equipment Manager will require those instruments to be pulled from service until repairs can be facilitated.

Field Operations Leader (FOL)/Field Team Leader (FTL) - The FOL/FTL shall ensure all field team members using monitoring instruments as part of their assigned duties are adequately trained in their proper operation and limitations. The FOL/FTL shall ensure that the air monitoring instruments are employed as directed by site guidance documents (i.e., Work Plan, Health and Safety Plan, etc.). Additionally, the FOL/FTL shall ensure that the appropriate documentation and recordkeeping requirements are fulfilled including Documentation of Calibration and Direct Reading Instrument Response Data Sheets for air monitoring activities. On projects where a dedicated SSO is not assigned, the FOL/FTL is responsible for assuming the duties of that position.

Health and Safety Officer (HSO) - The HSO is responsible for determining air monitoring requirements for the site activities, and providing direction for air monitoring during specific site activities. This identification of types of air monitoring and direction for use are indicated within the Site-Specific Health and Safety Plan (HASp).

Site Safety Officer (SSO) - The SSO shall ensure the instruments identified are employed in the manner directed by the HSO and action levels employed as contingencies marks for the application of engineering controls, personal protective equipment (PPE) use, and administrative controls are employed as directed. Additionally, he/she shall ensure the instruments are properly maintained and calibrated prior to use in the field. The SSO during specific air monitoring applications including STEL and TWA mode measurements will be responsible for operation and application of this specialty air monitoring employment duty. The

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 3 of 20
	Revision 1	Effective Date 06/99

SSO is also responsible for addressing relevant Hazard Communication requirements (e.g., MSDS, chemical inventories, labeling, training, etc.) on each assigned project.

5.0 PROCEDURES

5.1 General

Direct-reading instruments such as a flame ionization detector are typically used to monitor for airborne releases that could present an inhalation threat to personnel, and to screen and bias environmental samples. Proper use of these instruments by trained, qualified personnel is essential to the validity of any acquired results. Also essential is that the devices are properly calibrated according to manufacturers instructions (and the specifications of this SOP), and that users of the instrument properly document results.

5.2 Use and Documentation of Results

As with any direct-reading instrument, understanding not only how - but when to use this instrument is essential to gathering relevant and valid data. This device will only respond to volatile organics in air that are combustible. Inappropriate instrument selection, use, or interpretation of instrument results by an unqualified user not only can yield inaccurate results, but could place personnel at risk of exposure to hazardous agents. Only personnel who are properly trained and authorized to use this device will be permitted to operate it.

It is essential that instrument operators understand and comply with the requirements to document results. This includes the need to document calibration results as well as operational readings. Calibration results must be recorded using Figure 5-1. Operational results can be recorded in several ways, including:

- Direct-Reading Instrument Response Data (Figure 5-2) - preferred method
- Boring Log Forms (Figure 5-3)
- Test Pit Log Forms (Figure 5-4)
- Log book entries

When using direct-reading instruments, it is important to monitor the air near the source of potential releases (e.g., drilling boreholes, tank entrances, drum openings, etc.) and at worker breathing zone areas. All readings should be recorded, including readings noted where background levels were not exceeded.

5.3 Principles of Operation

The MicroFID is a flame ionization detector used for the measurement of combustible organic compounds in air at parts per million levels. Permanent air gases (argon, carbon dioxide, nitrogen, oxygen, water vapor, etc.) are not ionized by the flame.

When the MicroFID is turned on, the display prompts you to turn on the hydrogen. The internal pump draws sample air in through MicroFID's inlet. This sample air provides the oxygen necessary for combustion in the hydrogen-fueled flame. When the proper ratio of hydrogen to air is present in the combustion chamber, the flame is automatically started with a glow plug. A thermocouple is used to monitor the status of the flame. When the sample passes through the flame the combustible organic compounds in the sample will be ionized. After the compounds have been ionized, they are subjected to

Page

4 of 20

Effective Date

06/99

DOCUMENTATION OF FIELD CALIBRATION

PROJECT NO.: _____

[illegible]

5 of 20

06/99

DIRECT-READING INSTRUMENT RESPONSE DATA

PROJECT NO.: _____

PAGE OF

[illegible]

PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR

Number

ME-15

Page

6 of 20

Revision

—

Effective Date

06/99

FIGURE 5-2 (Continued)

SITE NAME: _____

PROJECT NO.: _____

PAGE _____ OF _____

[illegible]

Page ____ of ____

BORING NUMBER: _____
DATE: _____
GEOLOGIST: _____
DRILLER: _____

* When rock caving, enter rock brokenness.

== Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

Remarks:

Drilling Area
Background (ppm):

Converted to Well:	Yes	No	Well I.D. #:

FIGURE 5-4

TEST PIT LOG

Page ____ of ____

PROJECT NAME:

PROJECT NAME:
PROJECT NUMBER:

LOCATION:

TEST PIT NUMBER:

DATE:

GEOLOGIST:

[illegible]

TEST PIT CROSS SECTION AND / OR PLAN VIEW

REMARKS:

PHOTO LOG:

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 9 of 20
	Revision 1	Effective Date 06/99

a continuous electric field between the repeller electrode at the jet and the collector electrode. The ions in the electric field generate a current which is proportional to the concentration of the ionized molecules in the ionization chamber. An electrometer circuit converts the current to a voltage that is then fed to the microprocessor which interprets the current in units of ppm. After the sample passes through the flame and has become ionized, it is vented from the detector through a flame arrestor. The flame arrestor prevents the flame from igniting any flammable gases present in the working atmosphere.

MicroFID is strictly an organic compound detector. It does not respond to inorganic compounds. MicroFID's sensitivity is highly dependent on chemical structure and bonding characteristics. The combustion efficiency of a compound determines its sensitivity. Simple saturated hydrocarbons (methane, ethane, etc.) possess high combustion efficiencies and are among the compounds that produce the highest MicroFID response. Organic fuels (acetylene, refined petroleum products), burn easily and are also extremely well detected.

The presence of substituted functional groups (amino, hydroxyl, halogens) on a simple hydrocarbon reduces its combustion efficiency and the MicroFID's sensitivity to the compound. For example, methanol and chloromethane are detectable with MicroFID, but not at the same sensitivity as methane. The number of carbon atoms can also affect the instrument's sensitivity due to substitution. For example, MicroFID is more sensitive to n-butanol than it is to methanol. For additional information regarding response factors of the MicroFID, consult the manufacturer's of the User's Manual.

Beginning Operation

The MicroFID can be operated without the activation of the flame to print or review logged data. In this way, the hydrogen fuel is conserved.

MicroFID will attempt to ignite the flame once the flow of hydrogen gas has been started. If the MicroFID has not been used for a while, it is possible that the gas supply lines are filled with air. If the flame cannot be started, MicroFID will begin a 30 second purge cycle. During the purge cycle it will flush the gas supply lines with hydrogen. After the purge cycle, it will attempt to light the flame again. If it fails again, another purge cycle will be performed and MicroFID will try a third time to ignite the flame. The following steps summarize proper start-up procedures.

1. Turn the instrument on by pressing the front of the On/Off switch. When the instrument is powered up, the version number and creation date of the instrument software are displayed. Press ENTER.
2. You will be prompted to start the flame. If you do not want to start the flame, use the ARROW keys to select "No Flame Needed" and press ENTER. To start the flame, use the ARROW keys to select Start Flame and press ENTER.
3. If you selected "Start Flame," MicroFID will prompt you to turn on the hydrogen. Turn the shut-off valve counterclockwise to start the flow of hydrogen and press ENTER.
4. The pump will start and MicroFID will then ignite the flame. You will hear a small pop when the flame has been ignited. Once the flame has been started the message "Detector flame has been started OK" will be displayed followed by the default display.

The default display provides the following information: instrument status, current detected concentration, event name (if the datalogger is on), time, and date. If an event name is longer than three characters, the bottom line of the display will scroll through the information.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 10 of 20
	Revision 1	Effective Date 06/99

The instrument status appears at the left of the upper line of the display and on the Print and Graph outputs. Each status has a priority assigned to it. If more than one status is in effect, then the status with the highest priority is displayed until the condition is corrected or until the option is turned off.

5.4 Calibration

The calibration (CAL) key is used to calibrate MicroFID. Before beginning calibration, ensure that you have a reliable source of both zero air and calibration gas. To document calibration efforts, field personnel will record information on the Documentation of Field Calibration Form (Figure 5-1), or the same information in the calibration/maintenance log book assigned to an instrument. A brief description of the functions under the CAL key are as follows:

1. When you press the CAL key you will first be prompted to select a Cal Memory. Each Cal Memory stores a unique zero point, sensitivity setting, response factor and alarm level.
2. You will then be prompted to enter a response factor. Refer to the manufacturer's User's Manual for a list of response factors. If the compound is not listed in that reference, or if you are measuring gas mixtures, enter a value of 1.00. The concentration detected by MicroFID will be multiplied by the response factor before it is displayed and logged.
3. Next select Low Range or High Range operation. Use Low Range if you are sampling concentrations between 0.5 and 2000 ppm (methane equivalents). Use High Range if you are sampling concentrations between 10 and 50,000 ppm (methane equivalents).
4. You will now be prompted to connect a supply of zero air. You may use ambient air or, for best results, use a clean Tedlar bag filled with zero grade air. In most cases, ambient air will be used provided calibration is performed in an area in which interfering airborne contaminants are not present. If using ambient air, press <ENTER> to begin zeroing.
5. If you are using a charcoal filter to clean ambient air, connect the filter by loading the Teflon ferrules into the nut (the ferrules and the nut are supplied with the filter). Connect the nut to MicroFID's inlet. Do not tighten the nut. Remove the charcoal filter from its plastic bag and insert it into the nut. Finger tighten the nut onto the inlet. If the filter is not secure, ensure you have inserted the tube far enough into the nut. Do not over-tighten the fitting. Press <ENTER> and the MicroFID will set its zero point. NOTE: The charcoal filter does not filter methane or ethane. If these compounds are present, use a gas bag with a supply of commercial zero air.
6. If you are using a Tedlar bag filled with zero air, connect the bag to the inlet. Open the bag and press <ENTER>. MicroFID will set its zero point.
7. After MicroFID has set its zero point, you can then enter the concentration of the calibration gas (span gas), and then connect the Tedlar bag adapter to the inlet. Open the bag and press <ENTER>. MicroFID sets its sensitivity. Note: You must have a supply of calibration gas ready before calibrating MicroFID. When calibrating MicroFID, ensure the instrument is level. If MicroFID is tilted from side to side, gravity will affect the flame height and cause erroneous readings.
8. When MicroFID's display reverts to normal, it is calibrated and ready for use. Remove the Tedlar bag from the inlet.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 11 of 20
	Revision 1	Effective Date 06/99

9. Press the ALARM key and enter the alarm level for the selected CAL memory.

5.5 Routine Maintenance

5.5.1 Battery Charging

A fully charged battery will power the MicroFID for approximately 15 hours. If the instrument is to be used for more than 15 hours, carry a spare battery pack. Battery life is reduced if the instrument is turned off and then on again repeatedly.

When the instrument status displays "LoBat," the battery pack requires changing. When the "LoBat" status is displayed, you have a few minutes of operation left. MicroFID will turn itself off before the battery pack becomes critically low.

To remove the battery pack:

1. Stop the flow of hydrogen gas by turning the hydrogen shut-off valve fully clockwise. Turn the instrument off by pressing the On/Off switch twice.
2. Use the MicroFID multi-tool to loosen the two captive screws in the bottom of the battery pack.
3. A retainer at the rear of the instrument helps secure the battery pack to the instrument. Free the battery pack from the instrument.
4. Connect the charged battery pack to the retainer at the rear of the instrument.
5. Retighten the two captive screws and the bottom of the battery pack.

To charge the battery pack:

1. Ensure the correct plug is installed on the line cord of the battery charger.
2. Plug the charger into the jack located on the front of the battery pack.
3. Plug the charger into an AC outlet. The LED, on the battery pack indicates the charge state. Red indicates the battery is being charged. Green indicates the battery is fully charged and ready for use. It is normal for a fully charged battery to indicate it is charging (red light) when first plugged in. The LED will turn green as the battery charges.
4. When the battery pack is charged remove the charger, first from the wall outlet then from the battery pack.

Charging a fully discharged battery pack will take approximately 8 hours. Leaving the charger connected to a charged battery pack will not harm the battery or the charger in any way. If a battery pack is to be left indefinitely, leave it connected to the charger so that it will be fully charged and ready for operation.

5.5.2 Emptying the Hydrogen Cylinder

When you transport the MicroFID, you should empty the internal hydrogen cylinder and then refill it when you arrive at your destination.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 12 of 20
	Revision 1	Effective Date 06/99

To empty the cylinder:

1. Take the instrument outdoors, or to a well-ventilated area, at least 25 feet from any potential sources of ignition.
2. Turn the MicroFID off and open the hydrogen shut-off valve.
3. Remove the battery pack as described above.
4. Locate the purge outlet. It is located on the underside of the instrument.
5. Use the MicroFID multi-tool to turn the screws counterclockwise. Loosen the screw but do not remove it.
6. Leave the instrument so that the purge outlet is facing up. If the purge outlet is facing down, hydrogen will vent into MicroFID's case.
7. If the cylinder is full, it will take approximately 15 minutes to empty.
8. Watch the Contents gauge. When the cylinder is empty, close the purge outlet. Use the MicroFID multi-tool to turn the screw clockwise.
9. Replace the battery pack as discussed above.

5.5.3 Replacing the Sample Inlet Filter

MicroFID is equipped with a combined dust and water filter to reduce detector contamination. As the filter collects dust, MicroFID's inlet flow rate and sensitivity decrease. The filter will not allow water to pass through, but the filter will not stop gases and vapors.

Replace the filter on a weekly basis, or more frequently if MicroFID is used in a dusty or wet environment. You must replace the filter if MicroFID has been exposed to liquid water. The pump will sound labored when the filter requires replacement.

1. Turn off the instrument and unscrew the filter housing from the detector housing. Be careful not to lose the o-ring seal.
2. Remove the Teflon/Polypropylene filter and install the new filter. Place the filter in the filter housing with the Teflon side facing down into the filter housing and the mesh side facing the MicroFID. Handle the filter disk only by the edges. The mesh may be damaged or contaminated by excessive handling. Use forceps if possible.
3. Replace the filter housing.
4. Calibrate the CAL Memories that you are using before continuing operation.

5.6 Troubleshooting

This section provides guidance for troubleshooting the MicroFID. If problems are not corrected through these troubleshooting methods, contact the Photovac Service Department.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 13 of 20
	Revision 1	Effective Date 06/99

5.6.1 MicroFID Fault Messages

When the "Check" status is displayed, MicroFID's operation is compromised. Press the <TUTOR> key for a two-line description of the fault. One exception is the flame out fault. When a flame out fault occurs, the instrument status changes to "NoFlm."

Fault: Detector flame has gone out.

Cause: The hydrogen gas has run out.

Action: Ensure the shut-off valve is open. Check the hydrogen contents gauge on the side of the instrument and refill the hydrogen cylinder if necessary. Ensure the cylinder purge outlet has been closed.

Cause: Oxygen supply is deficient (Note: This is a Level B PPE condition).

Action: Ensure there is an adequate supply of oxygen. If you are sampling very high concentrations it is possible you are sampling above the flame out concentration. The flame out concentration for methane is approximately 52,000 ppm (5.2 percent methane in air).

A minimum of 17 percent oxygen is required to start the hydrogen flame. The oxygen is supplied from the sample as it is drawn in by the pump. A minimum of 10 percent oxygen is required to maintain the hydrogen flame.

Flame out also may occur when sampling enclosed or confined spaces where vapors and gases cannot escape. Watch for indications of increased flame height such as erratic readings or sudden high concentrations followed by a flame out fault.

If you will be using the MicroFID in a highly contaminated area where it is possible that the oxygen content will fall below 10 percent, watch for indication of reduced flame height such as lowered detection limits or a flame out fault.

Cause: High concentrations of flammable gases (gases within their flammable range) are present. High concentrations of flammable gases can act as an additional fuel source. When this happens, the flame height may increase beyond the confines of the combustion chamber. The hydrogen supply will then be cut-off and the flame will go out. Monitor LEL conditions and observe action levels specified in the Health and Safety Plan.

Action: Move to a location where there is an adequate supply of air and restart the flame. See the information above. Watch for indications of increased flame height such as erratic readings or sudden height concentrations followed by a flame out fault.

Caus : Exhaust port is blocked.

Action: At low temperatures, water vapor, a by-product of the hydrogen flame, may condense at the exhaust port. At sub-zero temperatures the water will freeze and obstruct the exhaust port. If the exhaust port becomes obstructed, pump operation will be inhibited. Flame out may also result. Operate the MicroFID within the operating temperature range 41 to 105 degrees Fahrenheit. In the event that the flame arrestor becomes clogged, contact the Photovac Service Department.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 14 of 20
	Revision 1	Effective Date 06/99

Cause: Sample line is blocked.

Action: Ensure the sample line is not obstructed in any way. If you are using the long sample probe, ensure flow is maintained through the entire length of tubing.

Cause: Inlet filter is plugged.

Action: Replace the inlet filter.

Fault: Signal from zero gas is too high.

Cause: Contamination of sample line or fittings before the detector.

Action: Clean or replace the sample line of the inlet filter.

Cause: Span gas is used instead of zero gas.

Action: Ensure clean gas is used to zero the MicroFID. Mark the calibration and zero gas Tedlar bags clearly.

Cause: Ambient air is contaminated.

Action: If you are unsure about the quality of the ambient air, use a charcoal filter or a supply of commercial zero grade air.

Caus : Hydrogen supply is contaminated.

Action: Hydrogen may react with the carbon element of the steel tank to produce methane. This will only occur if the cylinder is in poor condition and if the hydrogen has a high moisture content. Replace the hydrogen tank. Empty and refill the MicroFID internal cylinder with fresh hydrogen.

Fault: Signal from the calibration gas is too small

Caus : Calibration gas and zero air are switched.

Action: Ensure calibration gas is used to calibrate the MicroFID. Mark the calibration and zero gas Tedlar bags clearly. Ensure the calibration gas is of a reliable concentration.

Fault: Detector field voltage is low.

Caus : Internal fault in electronics.

Action: Contact the Photovac Service Department.

Probl m: No instrument response detected, yet compounds are known to be present.

Caus : MicroFID has not been calibrated properly.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 15 of 20
	Revision 1	Effective Date 06/99

Action: Ensure calibration gas is of a reliable concentration and then calibrate the instrument. After the instrument has been calibrated, sample the Tedlar bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not, contact the Photovac Service Department.

Action: When calibrating the MicroFID, ensure the instrument is level. If the MicroFID is tilted side to side, gravity can affect the flame height and cause erroneous readings. If the sampling location is difficult to reach without tilting the instrument, use the long sample probe.

Cause: Background contamination from the hydrogen.

Action: It is possible that the hydrogen has become contaminated and is contributing a high background signal. If the hydrogen supply tank is more than 6 months old it should be replaced with a new cylinder. When ordering hydrogen, specify ultra-high purity (99.999 percent pure). Empty the MicroFID hydrogen cylinder (as described in Section 5.5.2 of this SOP) and then refill with hydrogen from the new cylinder.

Problem: **Date and time settings are not retained.**

Cause: MicroFID has not been used for 3 months or more and the internal battery (not the external battery pack) has been discharged.

Action: Turn MicroFID on and allow it to run until a "LoBat" status appears. This will take approximately 15 hours. Remove the battery pack and recharge it overnight. Repeat this procedure for 3 or 4 days. While MicroFID is running the internal battery is charging.

Problem: **Cannot fill the internal hydrogen cylinder to 1800 psi.**

Cause: Supply tank has less than 1800 psi of pressure. You can only fill the internal cylinder to a pressure of less than or equal to the tank pressure.

Action: Fill the internal cylinder to the pressure of the tank or replace the tank with a full one.

Cause: The hydrogen purge outlet is open.

Action: Close the outlet and fill the cylinder.

Caus : There is a problem with the refill adapter.

Action: Contact the Photovac Service Department

Problem: **Instrument status shows "Over."**

Cause: Rapid change in signal level. The detector electronics have been momentarily saturated.

Action: Wait a few seconds for the status to return to "Ready."

Cause: The detector has become saturated.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 16 of 20
	Revision 1	Effective Date 06/99

Action: Move the MicroFID to a location where it can sample clean air. Sample zero air until the reading stabilizes around "0." If you were using Low Range, switch to High Range. Calibrate the CAL Memory you were using when the "Over" status appeared.

Problem: Display contrast bars are on or display is blank.

Caus : Battery pack is critically low.

Action: Recharge the battery pack or connect the MicroFID to the battery charger.

Caus : The battery pack is not connected to the instrument properly.

Action: Ensure the battery pack has been aligned correctly. Ensure the battery pack is secured by the retainer at the rear of the instrument.

Problem: Sample flow rate varies from 600 ml/min. +/-10 percent.

Caus : Inlet filter has not been installed.

Action: Install an inlet filter.

Caus : Inlet filter has not been properly tightened onto the detector cap.

Action: Finger-tighten the filter cap.

Caus : Inlet filter is plugged.

Action: Replace the inlet filter.

Caus : Pump has been damaged.

Action: Contact the Photovac Service Department

Caus : Exhaust port is blocked.

Action: At low temperatures, water vapor (a by-product of the hydrogen flame) may condense at the exhaust port. At sub-zero temperatures the water will freeze and obstruct the exhaust port. If the exhaust port becomes obstructed, pump operation will be inhibited. Flame out may also result. Operate the MicroFID within the operating temperature range 41 to 105 degrees Fahrenheit. In the event that the flame arrestor becomes clogged, contact the Photovac Service Department.

Problem: Flame will not ignite.

Cause: The hydrogen gas has run out.

Action: Ensure the shut-off valve is open. Check the hydrogen contents gauge on the side of the instrument and refill the hydrogen cylinder if necessary. Ensure the hydrogen purge outlet is closed.

Cause: Oxygen supply is deficient.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 17 of 20
	Revision 1	Effective Date 06/99

Action: Ensure there is an adequate supply of oxygen. Do not attempt to ignite the flame in a location where there is the suspicion of encountering greater than 10,000 ppm methane or the equivalent concentration of a flammable gas. Move to a location where there are lower concentrations, start the flame and then begin sampling higher concentrations. Monitor for LEL conditions, following action levels specified in the Health and Safety Plan. If the flame goes out while you are sampling very high concentrations, it is possible you are sampling above the flame out concentration. The flame out concentration of methane is approximately 52,000 ppm (5.2 percent methane in air). A minimum of 17 percent oxygen is required to start the hydrogen flame. Oxygen is supplied from the sample as it is drawn in by the pump. A minimum of 10 percent oxygen is required to maintain the hydrogen flame.

Cause: Exhaust port is blocked.

Action: At low temperatures, water vapor (a by-product of the hydrogen flame) may condense at the exhaust port. At sub-zero temperatures the water will freeze and obstruct the exhaust port. If the exhaust port becomes obstructed, pump operation will be inhibited. Flame out may also result. Operate the MicroFID within the operating temperature range 41 to 105 degrees Fahrenheit. In the event that the flame arrestor becomes clogged, contact the Photovac Service Department.

Caus : Hydrogen supply lines are full of air.

Action: If MicroFID has not been operated for some time, it is possible that the hydrogen supply lines contain air. Fill the hydrogen cylinder and then open the hydrogen shut-off valve. Allow the hydrogen to purge the system for about 5 minutes and then turn MicroFID on and start the flame.

Cause: Hydrogen lines are blocked.

Action: Contact the Photovac Service Department.

Problem: Liquid has been aspirated.

Cause: MicroFID has been exposed to a solvent that can pass through the Teflon/Polypropylene filter.

Action: Contact the Photovac Service Department.

5.7 Transporting MicroFID

When you transport MicroFID, you should empty the internal hydrogen cylinder and then refill it when you arrive at your destination (see Section 5.5.2 of this SOP). If you are traveling by passenger aircraft, you must empty the hydrogen cylinder. You cannot transport MicroFID by passenger aircraft with hydrogen in the cylinder.

The MicroFID can be shipped to sites. However, if shipment is to be performed while the cylinder still contains hydrogen, a Hazardous Materials Airbill must be filled out and the package must be properly marked and labeled. Examples of various completed forms are provided as Figures 6-1 and 6-2.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 18 of 20
	Revision 1	Effective Date 06/99

6.0 SHIPPING

The Photovac may be shipped as cargo or carried on as luggage providing there is no hydrogen fuel source or calibration gas cylinder accompanying the kit. **Only personnel who have been properly trained are permitted to offer a hazardous material for shipment.** The "Shipping Hazardous Materials" course offered by Tetra Tech NUS is considered acceptable training for this purpose. Specific instructions on packaging, labeling, and otherwise preparing a hazardous material shipment are presented in the Student Manual that accompanies the course. If shipping or transporting the hydrogen fuel source, a Hazardous Materials (or Dangerous Goods) Airbill such as the example in Figure 6-1 must be completed. When shipping or transporting the calibration gas, a separate Airbill (such as the one illustrated in Figure 6-2) must be prepared.

7.0 REFERENCES

MicroFID Handheld Flame Ionization Detector User's Manual, 1995.

Student Manual from "Shipping Hazardous Materials" course, Tetra Tech NUS, 1999.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 19 of 20
	Revision 1	Effective Date 06/99

FIGURE 6-1

EXAMPLE HAZARDOUS AIRBILL FOR HYDROGEN

FedEx <i>Dangerous Goods</i> 2887300 7180927 Airbill		Sender's Copy RETAIN FOR 1 YEAR RETAIN THIS COPY FOR YOUR RECORDS		<i>The World On Time.</i>																	
1 From (please print and press hard) Date _____ Sender's FedEx Account Number _____ Sender's Name _____ Phone () _____ Company _____ Address _____ Dept./Floor/Building _____ City _____ State _____ ZIP _____																					
2 Your Internal Billing Reference Information (Required: Please see statement will appear on invoice)																					
3 To (please print and press hard) Recipient's Name TON PATTON Phone (412) 262-4583 Company TETRA TECH NUS Address SPRING RUN RD EXT STE 140 B 1 City CORACOPUS State PA ZIP 15108 City _____ State _____ ZIP _____																					
4 Your Internal Billing Reference Information (Required: Please see statement will appear on invoice)																					
5 Packaging <input checked="" type="checkbox"/> Other Packaging Dangerous Goods cannot be shipped in FedEx packaging.																					
6 Special Handling <input checked="" type="checkbox"/> Dangerous Goods as per attached Shipper's Declaration <input checked="" type="checkbox"/> Cargo Aircraft Only																					
7 Payment Bill to <input type="checkbox"/> Sender <input type="checkbox"/> Recipient <input type="checkbox"/> Third Party <input type="checkbox"/> Credit Card <input type="checkbox"/> Cash/Check FedEx Account No. _____ Credit Card No. _____ Total Packages _____ Total Weight _____ Total Declared Value \$ _____																					
8 Express Package Service Packages under \$500 lbs. <input type="checkbox"/> FedEx Priority Overnight <input type="checkbox"/> FedEx Standard Overnight <input type="checkbox"/> FedEx 2Day <input type="checkbox"/> FedEx Express Saver 9 Express Freight Service Packages over \$500 lbs. <input type="checkbox"/> FedEx Overnight Freight <input type="checkbox"/> FedEx 2Day Freight <input type="checkbox"/> FedEx Express Saver Freight																					
TRANSPORT DETAILS This shipment is subject to the International Dangerous Goods Regulations (ICAO/IATA) and the U.S. Department of Transportation (DOT) Hazardous Materials Regulations (HMR). Shipment type: (Select one: Radioactive, Non-Radioactive, Infectious, Biohazard, Corrosive, Flammable, Oxidizing, Poisonous, Other) NON-RADIOACTIVE																					
NATURE AND QUANTITY OF DANGEROUS GOODS <table border="1"> <thead> <tr> <th>Proper Shipping Name</th> <th>Class or Division</th> <th>UN or ID No.</th> <th>Packing Group</th> <th>Subsidiary Risk</th> <th>Quantity and Type of Packaging</th> <th>Packing Inst.</th> <th>Authorization</th> </tr> </thead> <tbody> <tr> <td>Hydrogen Compressed</td> <td>2.1</td> <td>UN 1049</td> <td></td> <td></td> <td>1 Plastic Box 1.0 Kg</td> <td>200</td> <td></td> </tr> </tbody> </table>						Proper Shipping Name	Class or Division	UN or ID No.	Packing Group	Subsidiary Risk	Quantity and Type of Packaging	Packing Inst.	Authorization	Hydrogen Compressed	2.1	UN 1049			1 Plastic Box 1.0 Kg	200	
Proper Shipping Name	Class or Division	UN or ID No.	Packing Group	Subsidiary Risk	Quantity and Type of Packaging	Packing Inst.	Authorization														
Hydrogen Compressed	2.1	UN 1049			1 Plastic Box 1.0 Kg	200															
Additional Handling Information Prepared for AIR TRANSPORT according to: (Customer MUST check one) <input type="checkbox"/> 48 CFR <input checked="" type="checkbox"/> ICAO / IATA																					
I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packaged, marked, and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. Emergency Telephone Number (Required for US Origin or Destination Shipments) 1-800-535-5053 Intotrak																					
IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.																					

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 20 of 20
	Revision 1	Effective Date 06/99

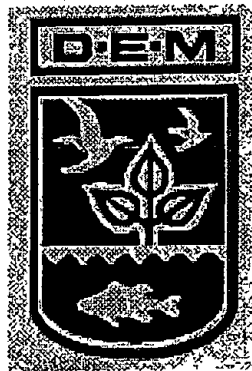
FIGURE 6-2

EXAMPLE HAZARDOUS AIRBILL FOR METHANE IN AIR

FedEx <i>Dangerous Goods</i> 7181160 <i>Airbill</i>		Sender's Copy RETAIN THIS COPY FOR YOUR RECORDS		<i>The World On Time.</i>																	
From (please print and press hard) _____ Date _____ Sender's FedEx Account Number _____ Sender's Name _____ Phone () _____ Company _____ Address _____ Dept./Floor/Room _____ City _____ State _____ ZIP _____																					
To (please print and press hard) Recipient's Name Tom Patton Phone 412-262-4583 Company Tetra Tech NUS Address Spring Run Road Extension, Suite 140 City Coraopolis State PA ZIP 15108																					
For HOLD at FedEx Location check here <input type="checkbox"/> Hold Warehouse <input type="checkbox"/> Hold Saturday (not available for FedEx Priority Overnight and FedEx 2Day only) For WEEKEND Delivery check here <input type="checkbox"/> Saturday Delivery (available for FedEx Priority Overnight and FedEx 2Day only) <input type="checkbox"/> NEW Sunday Delivery (available for FedEx Priority Overnight only)																					
Express Package Service Packages under 100 lbs. <input type="checkbox"/> FedEx Priority Overnight (next business day) <input type="checkbox"/> FedEx Standard Overnight (second business day) <input type="checkbox"/> FedEx 2Day (second business day) <input type="checkbox"/> FedEx Express Saver (third business day)																					
Express Freight Service Packages over 100 lbs. <input type="checkbox"/> FedEx Overnight Freight (next business day) <input type="checkbox"/> FedEx 2Day Freight (second business day) <input type="checkbox"/> FedEx Express Saver Freight (third business day)																					
Page 1 of 1 Pages																					
TRANSPORT DETAILS This shipment is subject to the Dangerous Goods Regulations. (Indicate any exceptions.) Hazardous Material Description: XXXXXXXXXX Hazardous Material Class: XXXXXXXXXX Hazardous Material Label: XXXXXXXXXX Airport of Departure: _____ Airport of Destination: _____		WARNING Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties. This Declaration must not, in any circumstances, be completed and/or signed by a consignor, a forwarder or an IATA cargo agent. Shipment type: (Indicate non-applicable) <input checked="" type="checkbox"/> NON-RADIOACTIVE XXXXXXXXXX																			
NATURE AND QUANTITY OF DANGEROUS GOODS <table border="1"> <thead> <tr> <th>Proper Shipping Name</th> <th>Class or Division</th> <th>UN or ID No.</th> <th>Packing Group</th> <th>Subsidiary Risk</th> <th>Quantity and Type of Packaging</th> <th>Packing Inst.</th> <th>Authorization</th> </tr> </thead> <tbody> <tr> <td>Compressed Gas N.O.S. (mixture Nitrogen and Oxygen)</td> <td>2.2</td> <td>UN 1956</td> <td></td> <td></td> <td>1 Plastic box x 0.55 Kg</td> <td>200</td> <td></td> </tr> </tbody> </table>						Proper Shipping Name	Class or Division	UN or ID No.	Packing Group	Subsidiary Risk	Quantity and Type of Packaging	Packing Inst.	Authorization	Compressed Gas N.O.S. (mixture Nitrogen and Oxygen)	2.2	UN 1956			1 Plastic box x 0.55 Kg	200	
Proper Shipping Name	Class or Division	UN or ID No.	Packing Group	Subsidiary Risk	Quantity and Type of Packaging	Packing Inst.	Authorization														
Compressed Gas N.O.S. (mixture Nitrogen and Oxygen)	2.2	UN 1956			1 Plastic box x 0.55 Kg	200															
Additional Handling Information _____ Prepared for AIR TRANSPORT according to: (Customer MUST check one) <input type="checkbox"/> 49 CFR <input checked="" type="checkbox"/> ICAO / IATA																					
I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packaged, marked, and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. Emergency Telephone Number (Required for US Origin or Destination Shipments) 1-800-535-5053 InfoTRAC Name/Title of Signatory _____ Place and Date _____ Signature (see warning above) _____																					
IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT																					

**STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
Division of Groundwater and Individual Sewage Disposal Systems**

**Rules and Regulations for
GROUNDWATER QUALITY**



August 1996

Promulgated:	May 1992
Amended:	July 1993
	May 1995
	August 1996

Regulation 12-100-006

AUTHORITY: These Rules and Regulations are adopted in accordance with Chapter 42-35 pursuant to Chapters 46-12, 46-13.1, 23-18.9, 23-19.1, 42-17.6 and 42-17.1 of the Rhode Island General Laws of 1956, as amended

APPENDIX 1
Required Monitoring Well Construction Standards and Abandonment Procedures

- 1.0 Purpose: to provide minimum standards for; (a) the procurement of samples representative of groundwater; and (b) abandonment procedures for removing the vertical conduit to groundwater.
- 2.0 Applicability: The monitoring well construction standards herein apply to all permanent monitoring wells installed pursuant to these regulations. Pursuant to Rule 12.02 of these regulations, wells installed at the direction of other programs are exempt from Rules 4.0 through 12.0 of this Appendix. A monitoring well is designated permanent if it exists for more than 180 days. Rule 13 of this Appendix on monitoring well abandonment applies to all permanent and non-permanent monitoring wells subject to these regulations. Rule 13 also applies to those piezometers where improper abandonment would result in a reasonable likelihood of groundwater pollution. Additional requirements may be specified by the Director.
- 3.0 Prevention of Groundwater Pollution: During well construction and abandonment, every appropriate precaution shall be taken to prevent introducing pollutants into the groundwater. This shall include, but not be limited to, steam cleaning and washing of drilling equipment and proper cleaning and storage of well casing. Only potable water shall be used in well construction and abandonment unless otherwise approved by the Director.
- 4.0 Construction and Abandonment Standards: The procedures described in this Appendix incorporate minimum standards. The Director may waive the requirements and allow deviation from these procedures where such deviations are necessary to procure representative groundwater samples. All deviations from the procedures shall be documented and provided to the Director. If the Director determines that the deviation from these procedures will not or does not result in the procurement of samples representative of groundwater, the Director may require the installation of a new monitoring well.
- 5.0 Well Casing: All permanent groundwater monitoring wells shall be constructed of PVC well casing material. All casing shall have a minimum inside diameter of 2.0 inches. Monitoring wells constructed in unconsolidated material less than 100 feet in depth shall be constructed using a minimum of schedule 40 PVC. Wells greater than 100 feet shall be constructed using a minimum of schedule 80 PVC.
- 5.1 Assembly and Installation: All casing shall be constructed of flush threaded joints or threaded coupling joints. All joints shall be fitted with an "O" ring or wrapped with teflon tape. Solvent welded joints are not permissible without prior written permission of the Director.
- 5.2 Exceptions: The Director may allow alternate well casing material if the pollutant concentrations or geologic setting require an alternative construction. Alternative materials include but are not limited to: (a) Teflon; (b) stainless steel; or (c) uncoated or galvanized steel.
- 6.0 Well Screen: The well screen slot size shall retain at least 90% of the grain size of a filter pack or at least 60% of the grain size of the collapsed formation. Well screens on wells and piezometers shall not exceed the length necessary to collect a representative groundwater sample or to determine water table elevation. Well screens shall be factory slotted. A bottom cap and sump sediment trap shall be installed.
- 7.0 Filter Pack: The filter pack shall be chemically inert, well rounded and well sorted glass beads or silica-based sand or gravel of uniform grain size. The filter pack must minimize the amount of fine material entering the well and shall not inhibit the flow of water into the well. The filter pack shall extend a minimum of one foot, but no more than 5 feet above the well screen. The filter pack shall not pollute groundwater.

Sealing Requirements

- 8.1 Filter Pack Seal: All monitoring wells installed with a filter pack shall be constructed with a filter pack seal, such as bentonite flakes or pellets. The seal shall extend to approximately one foot above the filter pack and shall be properly hydrated.
- 8.2 Annular Space Seal: All monitoring wells shall be installed with an annular space seal that has a permeability of 1×10^{-7} centimeters per second or less. Materials that meet this criterion include but are not limited to neat cement grout and cement-bentonite grout. The annular space seal shall extend to the ground surface seal, except where a road box meeting the requirements of Rule 10.0 of this Appendix is used.
- 8.3 Ground Surface Seal: All monitoring wells shall be constructed with a continuous pour concrete ground surface seal. To avoid frost heaving and to anchor the well, the ground surface seal shall extend to a minimum of 40 inches below the land surface, unless the well meets one of the requirements of the exemption described in Rule 8.4 of this Appendix. The ground surface seal shall be flared such that the diameter at the top is greater than the diameter at the bottom. The top of the ground surface seal shall be sloped away from the well casing and shall be imprinted with the designation of the monitoring well.

8.4 Exemption from 40 Inch Ground Surface Seal Requirement: As stated in Rule 8.3 of this Appendix, the ground surface seal shall extend at least 40 inches down the hole from the land surface. Exemptions from this rule are limited to the following circumstances: 1) where the seal would interfere with proper placement or functioning of the well screen; and 2) where a road box is used and sand is placed inside and directly below the road box in such a way as to ensure that any seepage into the road box drains away from the well.

Protective Cover Pipe: The protective pipe shall consist of a minimum 4 inch diameter metal casing with locking cap. The protective pipe shall extend from the bottom of the ground surface seal to a minimum of 24 inches above the land surface. There shall be no more than 4 inches between the top of the well casing and the top of the protective pipe. The monitoring well designation shall be indicated clearly on the protective cover pipe. A gas vent and a drain hole shall be installed. A high visibility guard post to prevent destruction of the well may be required. The Director may request additional protective devices as necessary.

Road Box: Road boxes are acceptable in locations where protective cover pipes are not suitable. All road boxes shall be secured and water tight and prevent easy access to the well. The well shall be fitted with a locking, water tight cap. The ground surface seal for the road box shall be competent such that vehicle traffic will not cause it to fail. The annular space seal shall extend upward to within one foot of the ground surface seal. One or two feet of permeable material may be emplaced between the ground surface seal and the annular space seal in order to allow for the drainage of runoff which may leak into the road box from the ground surface.

Well Development: Development of all monitoring wells shall be performed no earlier than 48 hours after completion and before the initial water quality samples are taken. The goal of well development is to produce water free of fine sand, coarser material, drill cuttings, and drilling fluids. The formation shall be allowed to stabilize for at least 24 hours before groundwater sampling.

Innovative Well Installation: Innovative wells, including but not limited to Microwells or Geoprobes, that are small-diameter and are non-destructive to the formation, and which are capable of providing samples representative of groundwater, need not meet the construction requirements set forth in Rules 4.0 through 11.0 of this Appendix.

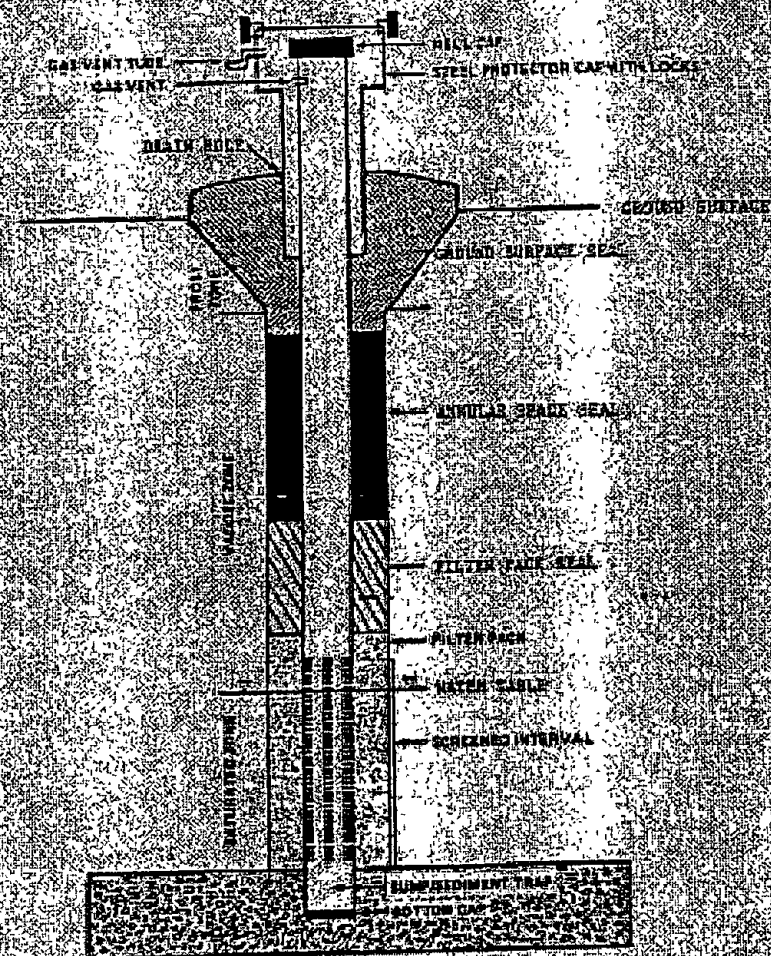
Monitoring Well and Piezometer Abandonment:

13.1 General:

- (a): All monitoring wells and applicable piezometers as described in Rule 1.0 of this Appendix that are no longer used to gather information on geologic or groundwater properties shall be abandoned pursuant to the provisions of Rule 13.2 of this Appendix. Well abandonment shall take place within 60 days after its use has been terminated, unless a written exemption is received from the Director for continued use.
- (b) Innovative wells: Innovative wells as described in Rule 12.0 of this Appendix shall be abandoned at the end of use in order to remove the conduit to groundwater. Abandonment of innovative wells shall consist of removal of the well and grouting of the borehole. Innovative wells are exempted from the abandonment procedures described in Rule 13.2 of this Appendix.

13.2 Abandonment Procedures: The well shall be inspected from the land surface through the entire depth of the well before it is sealed to ensure against the presence of any obstructions that will interfere with sealing operations.

- (a) Wells constructed with an impermeable annular seal shall be abandoned by cutting off the casing a minimum of 4 feet below land surface. The remaining casing shall be completely filled with a neat cement grout or bentonite-cement grout. The remaining hole volume shall be backfilled with natural material, with the following exception: where backfilling with natural material would result in a grout plug less than 4 feet long, the hole shall be filled to approximately one foot from the ground surface with the neat cement grout or bentonite-cement grout.
- (b) Wells not known to be constructed with an impermeable annular seal shall be abandoned by completely removing the well casing and sealing with neat cement or bentonite-cement grout to approximately one foot from the ground surface. If the casing cannot be removed during the abandonment of a well, the casing shall be thoroughly ripped or perforated from top to bottom, except that perforations will not be required over intervals of the well that are sealed with cement. The screened portion of the well and the annular space between the casing and the drillhole wall shall be effectively and completely filled with cement or bentonite-cement grout applied under pressure.



CROSS-SECTION OF TYPICAL MONITORING WELL

After 42 EPA, 1986, RCRA Compliance Monitoring Technical Enforcement Guidance Document

**U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I**

**LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE
FOR THE COLLECTION OF GROUND WATER SAMPLES
FROM MONITORING WELLS**

I. SCOPE & APPLICATION

This standard operating procedure (SOP) provides a general framework for collecting ground water samples that are indicative of mobile organic and inorganic loads at ambient flow conditions (both the dissolved fraction and the fraction associated with mobile particulates). The SOP emphasizes the need to minimize stress by low water-level drawdowns, and low pumping rates (usually less than 1 liter/min) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed primarily at sampling monitoring wells that can accept a submersible pump and have a screen, or open interval length of 10 feet or less (this is the most common situation). However, this procedure is flexible and can be used in a variety of well construction and ground-water yield situations. Samples thus obtained are suitable for analyses of ground water contaminants (volatile and semi-volatile organic analytes, pesticides, PCBs, metals and other inorganics), or other naturally occurring analytes.

This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). For this the reader may wish to check: Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation; C.K. Smoley (CRC Press), Boca Raton, Florida and U.S. Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance; Washington, DC (EPA/530-R-93-001).

The screen, or open interval of the monitoring well should be optimally located (both laterally and vertically) to intercept existing contaminant plume(s) or along flowpaths of potential contaminant releases. It is presumed that the analytes of interest move (or potentially move) primarily through the more permeable zones within the screen, or open interval.

Use of trademark names does not imply endorsement by U.S.EPA but is intended only to assist in identification of a specific type of device.

Proper well construction and development cannot be overemphasized, since the use of installation techniques that are appropriate to the hydrogeologic setting often prevents "problem well" situations from occurring. It is also recommended that as part of development or redevelopment the well should be tested to determine the appropriate pumping rate to obtain stabilization of field indicator parameters with minimal drawdown in shortest amount of time. With this information field crews can then conduct purging and sampling in a more expeditious manner.

The mid-point of the saturated screen length (which should not exceed 10 feet) is used by convention as the location of the pump intake. However, significant chemical or permeability contrast(s) within the screen may require additional field work to determine the optimum vertical location(s) for the intake, and appropriate pumping rate(s) for purging and sampling more localized target zone(s). Primary flow zones (high(er) permeability and/or high(er) chemical concentrations) should be identified in wells with screen lengths longer than 10 feet, or in wells with open boreholes in bedrock. Targeting these zones for water sampling will help insure that the low stress procedure will not underestimate contaminant concentrations. The Sampling and Analysis Plan must provide clear instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the remaining criteria in this procedure are met. If after 4 hours of purging indicator field parameters have not stabilized, one of 3 optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization) c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may not meet the sampling objectives).

Changes to this SOP should be proposed and discussed when the site Sampling and Analysis Plan is submitted for approval. Subsequent requests for modifications of an approved plan must include adequate technical justification for proposed changes. All changes and modifications must be approved before implementation in field.

II. EQUIPMENT

A. Extraction device

Adjustable rate, submersible pumps are preferred (for example, centrifugal or bladder pump constructed of stainless steel or

Teflon).

Adjustable rate, peristaltic pumps (suction) may be used with caution. Note that EPA guidance states: "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" (EPA/540/P-87/001, 1987, page 8.5-11).

The use of inertial pumps is discouraged. These devices frequently cause greater disturbance during purging and sampling and are less easily controlled than the pumps listed above. This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

B. Tubing

Teflon or Teflon lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for inorganics analyses. However, these materials should be used with caution when sampling for organics. If these materials are used, the equipment blank (which includes the tubing) data must show that these materials do not add contaminants to the sample.

Stainless steel tubing may be used when sampling for VOCs, SVOCs, pesticides, and PCBs. However, it should be used with caution when sampling for metals.

The use of 1/4 inch or 3/8 inch (inner diameter) tubing is preferred. This will help ensure the tubing remains liquid filled when operating at very low pumping rates.

Pharmaceutical grade (Pharmed) tubing should be used for the section around the rotor head of a peristaltic pump, to minimize gaseous diffusion.

C. Water level measuring device(s), capable of measuring to 0.01 foot accuracy (electronic "tape", pressure transducer). Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level "tape" at the start and end of each record.

D. Flow measurement supplies (e.g., graduated cylinder and stop watch).

E. Interface probe, if needed.

F. Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate the samples.

G. Indicator field parameter monitoring instruments - pH, Eh, dissolved oxygen (DO), turbidity, specific conductance, and temperature. Use of a flow-through-cell is required when measuring all listed parameters, except turbidity. Standards to perform field calibration of instruments. Analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846. For Eh measurements, follow manufacturer's instructions.

H. Decontamination supplies (for example, non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.).

I. Logbook(s), and other forms (for example, well purging forms).

J. Sample Bottles.

K. Sample preservation supplies (as required by the analytical methods).

L. Sample tags or labels.

M. Well construction data, location map, field data from last sampling event.

N. Well keys.

O. Site specific Sample and Analysis Plan/Quality Assurance Project Plan.

P. PID or FID instrument (if appropriate) to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

III. PRELIMINARY SITE ACTIVITIES

Check well for security damage or evidence of tampering, record pertinent observations.

Lay out sheet of clean polyethylene for monitoring and sampling equipment.

Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook.

A synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft.) and

total well depth (to 0.1 ft.) be measured the day before, in order to allow for re-settlement of any particulates in the water column. If measurement of total well depth is not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe are usually not needed unless analytical data or field head space information signal a worsening situation. Note: procedures for collection of LNAPL and DNAPL samples are not addressed in this SOP.

IV. PURGING AND SAMPLING PROCEDURE

Sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

1. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. The Sampling and Analysis Plan should specify the sampling depth, or provide criteria for selection of intake depth for each well (see Section I). If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well. Collection of turbid free water samples may be especially difficult if there is two feet or less of standing water in the well.

2. Measure Water Level

Before starting pump, measure water level. If recording pressure transducer is used-initialize starting condition.

3. Purge Well

3a. Initial Low Stress Sampling Event

Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Check water level. Adjust pump speed until there is little or no water level drawdown (less than 0.3 feet). If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging until indicator field parameters stabilize.

Monitor and record water level and pumping rate every three to five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (for example, 0.1 - 0.4 l/min) to ensure stabilization of indicator

parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. Do not allow the water level to fall to the intake level (if the static water level is above the well screen, avoid lowering the water level into the screen). The final purge volume must be greater than the stabilized drawdown volume plus the extraction tubing volume.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (bladder, peristaltic), and/or the use of dedicated equipment. If the recharge rate of the well is lower than extraction rate capabilities of currently manufactured pumps and the well is essentially dewatered during purging, then the well should be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples (ideally the intake should not be moved during this recovery period). Samples may then be collected even though the indicator field parameters have not stabilized.

3b. Subsequent Low Stress Sampling Events

After synoptic water level measurement round, check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). Perform purging operations as above.

4. Monitor Indicator Field Parameters

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, Eh, DO) every three to five minutes (or less frequently, if appropriate). Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at three (3) to five (5) minute intervals, are within the following limits:

- turbidity (10% for values greater than 1 NTU),
- DO (10%),
- specific conductance (3%),
- temperature (3%),
- pH (± 0.1 unit),
- ORP/Eh (± 10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values

measured within the cell and may also cause an underestimation of turbidity values measured after the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities.

The flow-through-cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times. If two flow-through-cells are used in series, the one containing the dissolved oxygen probe should come first (this parameter is most susceptible to error if air leaks into the system).

5. Collect Water Samples

Water samples for laboratory analyses must be collected before water has passed through the flow-through-cell (use a by-pass assembly or disconnect cell to obtain sample).

VOC samples should be collected first and directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

During purging and sampling, the tubing should remain filled with water so as to minimize possible changes in water chemistry upon contact with the atmosphere. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use one of the following procedures to collect samples: (1) add clamp, connector (Teflon or stainless steel) or valve to constrict sampling end of tubing; (2) insert small diameter Teflon tubing into water filled portion of pump tubing allowing the end to protrude beyond the end of the pump tubing, collect sample from small diameter tubing; (3) collect non-VOC samples first, then increase flow rate slightly until the water completely fills the tubing, collect sample and record new drawdown, flow rate and new indicator field parameter values.

Add preservative, as required by analytical methods, to samples immediately after they are collected if the sample containers are not pre-preserved. Check analytical methods (e.g. EPA SW-846, water supply, etc.) for additional information on preservation. Check pH for all samples requiring pH adjustment to assure proper pH value. For VOC samples, this will require that a test sample be collected during purging to determine the amount of preservative that needs to be added to the sample containers prior to sampling.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter is required, and the filter

size (0.45 um is commonly used) should be based on the sampling objective. Pre-rinse the filter with approximately 25 - 50 ml of ground water prior to sample collection. Preserve filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in ground water for human health risk calculations.

Label each sample as collected. Samples requiring cooling (volatile organics, cyanide, etc.) will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

6. Post Sampling Activities

If recording pressure transducer is used, remeasure water level with tape.

After collection of the samples, the pump tubing may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth is optional after the initial low stress sampling event. However, it is recommended if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

V. DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the well) will be decontaminated by one of the procedures listed below.

Procedure 1

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Flush with isopropyl alcohol (pesticide grade). If equipment blank data from the previous sampling event show that the level of contaminants is insignificant, then this step may be skipped.

Flush with distilled/deionized water. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

VI. FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the ground water samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples shall be collected for each batch of samples (a batch may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one set per VOC sample cooler.

Field duplicate.

Matrix spike.

Matrix spike duplicate.

Equipment blank.

Trip blank (VOCs).

Temperature blank (one per sample cooler).

Equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank will only include the pump in subsequent sampling rounds.

Collect samples in order from wells with lowest contaminant concentration to highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

Field duplicates are collected to determine precision of sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

If split samples are to be collected, collect split for each analyte group in consecutive order (VOC original, VOC split, etc.). Split sample should be as identical as possible to original sample.

All monitoring instrumentation shall be operated in accordance with EPA analytical methods and manufacturer's operating instructions. EPA analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846 with exception of Eh, for which the manufacturer's instructions are to be followed. Instruments shall be calibrated at the beginning of each day. If a measurement falls outside the calibration range, the instrument should be re-calibrated so that all measurements fall within the calibration range. At the end of each day, check calibration to verify that instruments remained in calibration. Temperature measuring equipment, thermometers and thermistors, need not be calibrated to the above frequency. They should be checked for accuracy prior to field use according to EPA Methods and the manufacturer's instructions.

VII. FIELD LOGBOOK

A field log shall be kept to document all ground water field monitoring activities (see attached example matrix), and record all of the following:

Well identification.

Well depth, and measurement technique.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and

detection method.

Pumping rate, drawdown, indicator parameters values, and clock time, at the appropriate time intervals; calculated or measured total volume pumped.

Well sampling sequence and time of each sample collection.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analysis.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling equipment used, including trade names, model number, diameters, material composition, etc.

VIII. DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, and whatever field logbook information is needed to allow for a full evaluation of data useability.

EXAMPLE (Minimum Requirements)

Page of

Location (Site/Facility Name) _____ Depth to _____ / _____ of screen
Well Number _____ Date _____ (below MP) top / bottom
Field Personnel _____ Pump Intake at (ft. below MP) _____
Sampling Organization _____ Purging Device; (pump type) _____
Identify MP _____

[illegible]

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. μ Siemens per cm (same as μ mhos/cm) at 25 °C.
3. Oxidation reduction potential (stand in for Eh).

TOTAL VOLATILE ORGANIC COMPOUNDS JAR HEADSPACE SCREENING

The samples will be logged by the rig geologist, and standard headspace analysis will be performed using a flame ionization detector (FID) or photoionization detector (PID) field survey instrument as described below:

1. Half-fill one clean glass jar with the sample to be analyzed. Quickly cover each open jar top with one sheet of clean aluminum foil and subsequently apply the jar screw cap to tightly seal the jar. The jar must have a volume of 8 ounces or greater .
2. Shake the jar vigorously for 15 to 30 seconds and then allow the headspace to equilibrate for at least 10 minutes. When ambient temperatures are below 32 degrees F, the headspace equilibration should occur within a heated vehicle or building.
3. After headspace equilibration, remove the jar lid to expose the foil seal. Quickly puncture the foil seal with the FID probe tip, to a point approximately one-half of the available headspace depth. Exercise care when penetrating the foil seal in order to avoid uptake of water droplets or soil particulates.
4. Following the probe insertion through the foil seal, record the highest meter response as the total VOC headspace concentration. The maximum response should occur between 2 to 5 seconds after the insertion of the probe tip. Longer periods may create a vacuum inside the sample jar. Erratic meter response may occur at high VOC concentrations or conditions of elevated headspace water vapor in which case the headspace data should be considered suspect for that sample.

NOTE: The presence of methane can also interfere with the response of a FID instrument. FIDs have a very sensitive response to methane and which can mistakenly be considered as a high total VOC concentration. If methane is potentially present (e.g., landfill or wetland), a PID instrument may be substituted or used in unison with the FID. The PID instrument does not respond to methane, however high humidity can result in a poor VOC response.

APPENDIX C

TINUS FIELD DOCUMENTATION FORMS

GRD. SURFACE ELEVATION:

CHECKED BY:

ELEVATION FROM:

[illegible]

OTHER OBSERVATIONS:

Tetra Tech NUS, Inc.



BORING NO.:

PAGE: OF



TETRA TECH NUS, INC.

SAMPLE LOG SHEET - SOLID PHASE

Site Name: _____
 Sample ID: _____

Tetra Tech NUS Charge No. _____
 QC Information: _____ (if applicable)

Sample Method: _____
 Depth Sampled: _____ - feet
 Sample Date & Time: ____/____/____ _____ hours Dup ____ hours
 Sampler(s): _____

Data Recorded By: _____
 _____ Signature

PID/OVA Monitor Reading: _____ ppm

TYPE OF SAMPLE: (Check all that apply)

☐ Soil ☐ Trip Blank*
☐ Sediment ☐ Rinsate Blank*
☐ Lagoon/Pond ☐ Field Duplicate collected
☐ Grab ☐ Other (Specify): _____

Description: (Sand, Clay, Muck, Peat, Dry, Moist, Wet, Etc.) _____

SAMPLE DATA/REMARKS: _____

ANALYSIS	BOTTLE LOT NO.	NOTES/SKETCH:



TETRA TECH NUS, INC.

SAMPLE LOG SHEET - LIQUID PHASE

Site Name: _____
Sample ID: _____Tetra Tech NUS Charge No. _____
QC Information: _____ (if applicable)Sample Method/Device: _____
Depth Sampled: _____ feet Total Depth _____ feet (SW Only)
Sample Date & Time: ____/____/____ hours
Sampler(s): _____Recorded By: _____
Signature

TYPE OF SAMPLE: (Check all that apply)

☐ Groundwater
☐ Surface Water
☐ Residential Supply
☐ Grab
☐ Composite☐ Trip Blank*
☐ Rinsate Blank*
☐ Field Duplicate Collected
☐ Other (Specify): _____

* include sample source & lot No.

WELL PURGE DATA:

Well Depth	feet	Purge Start	hrs
Inside Diameter	inches	Purge Stop Time	hrs
Water Level	feet	Total Gallons Purged	
Well Volume	gal.	Purge Method	

Color: _____ Turbidity: CLR/SL CLDY/CLDY/OPAQ

Micro Tip/OVA Monitor Reading: _____ ppm

Sampling/Purge Data:

Vol. #	Temp °C	pH	Spec. Cond.	DO
0	_____	_____	_____	_____
1	_____	_____	_____	_____
3	_____	_____	_____	_____
4	_____	_____	_____	_____

ANALYSIS	BOTTLE LOT NO.	TRAFFIC REPORT NO.		COMMENTS
		ORGANIC	INORGANIC	



Sample Container Lot # _____

Date: _____

[illegible]

Note: Tare weight = vial, preservative, cap and magnetic stirrer, if applicable

Laboratory Analysts Initials: _____

Date: _____

FLUSH MOUNT MONITORING WELL CONSTRUCTION LOG

TETRA TECH NUS INC.

PROJECT NAME: _____		PROJECT NO: _____
PROJECT LOCATION: _____		WELL NO: _____
CLIENT: _____		BORING NO: _____
CONTRACTOR: _____	DRILLER: _____	BORING LOCATION: _____
LOGGED BY: _____	DATE: _____	
CHECKED BY: _____	DATE: _____	

PAGE: 1 OF 1

FLUSH MOUNT PROTECTIVE CASING

GROUND ELEVATION

SAND DRAIN LAYER

LENGTH RISER PIPE BELOW GRD. SURF.(Ft.)

TYPE OF SURFACE SEAL

DIA. SURFACE SEAL BGS (In.)

DEPTH TO BOTTOM OF SURFACE SEAL (Ft.)

I.D. OF PROTECTIVE CASING (In.)

TYPE OF PROTECTIVE CASING

DEPTH BOTTOM OF PROTECTIVE CASING (Ft.)

DEPTH BOTTOM OF DRAIN LAYER (Ft.)

RISER PIPE (In.) I.D.: O.D.:

TYPE OF RISER PIPE

TYPE OF BACKFILL AROUND RISER PIPE

DEPTH TOP OF SEAL (Ft.)

TYPE OF SEAL

DEPTH BOTTOM OF SEAL (Ft.)

DEPTH TOP OF PERVIOUS SECTION (Ft.)

DIAMETER OF BOREHOLE (In.)

TYPE OF PERVIOUS SECTION

TYPE OF OPENINGS

PERVIOUS SECTION (In.) I.D.: O.D.:

TYPE OF FILTER PACK AROUND PERVIOUS SECTION

DEPTH BOTTOM OF PERVIOUS SECTION (Ft.)

DEPTH BOTTOM OF FILTER PACK (Ft.)

TYPE OF BACKFILL (GROUT) BELOW FILTER PACK

END OF BORING

GENERAL NOTE:

1. Entry of 0.00 for Ground Elevation Indicates that Surveyed Ground Elevation is NOT Available.

OVERBURDEN MONITORING WELL CONSTRUCTION LOG

TETRA TECH NUS, INC.

PROJECT NAME: _____	PROJECT NO: _____
PROJECT LOCATION: _____	WELL NO: _____
CLIENT: _____	BORING NO: _____
CONTRACTOR: _____	BORING LOCATION: _____
LOGGED BY: _____	DATE: _____
CHECKED BY: _____	DATE: _____

PAGE: 1 OF 1

ELEVATION TOP OF PROTECTIVE CASING _____	LENGTH OF PROTECTIVE CASING ABOVE GROUND SURFACE (Ft.) _____
ELEVATION TOP OF RISER PIPE _____	LENGTH OF RISER PIPE ABOVE GROUND SURFACE (Ft.) _____
GROUND ELEVATION _____	
SAND DRAIN LAYER →	TYPE OF SURFACE SEAL _____
	DIA. SURFACE SEAL BGS (In.) _____
	DEPTH TO BOTTOM OF SURFACE SEAL (Ft.) _____
	I.D. OF PROTECTIVE CASING (In.) _____
	TYPE OF PROTECTIVE CASING _____
	DEPTH BOTTOM OF PROTECTIVE CASING (Ft.) _____
	DEPTH BOTTOM OF DRAIN LAYER (Ft.) _____
	RISER PIPE (In.) I.D.: _____ O.D.: _____
	TYPE OF RISER PIPE _____
	TYPE OF BACKFILL AROUND RISER PIPE _____
	DEPTH TOP OF SEAL (Ft.) _____
	TYPE OF SEAL _____
	DEPTH BOTTOM OF SEAL (Ft.) _____
	DEPTH TOP OF PERVIOUS SECTION (Ft.) _____
	DIAMETER OF BOREHOLE (In.) _____
	TYPE OF PERVIOUS SECTION _____
	TYPE OF OPENINGS _____
	PERVIOUS SECTION (In.) I.D.: _____ O.D.: _____
	TYPE OF FILTER PACK AROUND PERVIOUS SECTION _____
	DEPTH BOTTOM OF PERVIOUS SECTION (Ft.) _____
END OF BORING →	DEPTH BOTTOM OF FILTER PACK (Ft.) _____

GENERAL NOTE:

1. Entry of 0.00 for Ground Elevation, Elev. Top of Riser Pipe & Elev. Top of Protective Casing indicates that Surveyed Ground Elevation Not Available.



TETRA TECH NUS. INC.

FIELD INSTRUMENT CALIBRATION LOG

INSTRUMENT NAME: _____

MODEL No.: _____

SERIAL No.: _____

DECAL No.: _____

TETRA TECH NUS CHARGE No. _____

CALIBRATION DATE	INITIAL READING	PROCEDURE	FINAL READING	SIGNATURE	COMMENTS



TETRA TECH NUS, INC.

PHOTOIONIZATION DETECTOR FIELD CALIBRATION LOG

Serial No.: _____

Model No.: _____

Decal No.: _____

Site Name/Location: _____

Tetra Tech NUS Charge No.: _____

CALIBRATION DATE	STANDARD GAS- ISOBUTYLENE	CALIBRATION READING Isobutylene Equiv. (ppm)	CALIBRATION CHECK Isobutylene Equiv. (ppm)	SIGNATURE	COMMENTS
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				



PROJECT NAME: _____ TETRA TECH NUS JOB NO./PMS: _____

SAMPLING EVENT: _____ CASE NO.: _____ DAS NO.: _____

[illegible]



TETRA TECH NUS, INC.

YSI 6820 MULTIPARAMETER METER

Serial No.: _____ Model No.: _____ Decal No.: _____

Site Name: _____ Job No.: _____

Instrument is calibrated in accordance with Manufacturer's Instructions

DATE:	Pre Calibration Readings	Post Calibration Readings	PM Check	Calibration STDs (lot #'s)	Signature	Remarks
Cond. mS/cm						
pH = 4.0						
pH = 7.0						
pH = 10.0						
D.O. mg/l						
REDOX mV						
Turbidity 0 NTUs						
Turbidity 100 NTUs						
Temp °C						
Salinity 0/00						

DATE:						
Cond. mS/cm						
pH = 4.0						
pH = 7.0						
pH = 10.0						
D.O. mg/l						
REDOX mV						
Turbidity 0 NTUs						
Turbidity 100 NTUs						
Temp °C						
Salinity 0/00						



Serial No.: _____ Model No.: _____ Decal No.: _____
Site Name: _____ Job No.: _____ Buffer Lot No.: _____

Instrument is calibrated in accordance with Manufacturer's Instructions

[illegible]



TETRA TECH NUS, INC.

GROUNDWATER LEVEL MEASUREMENT SHEET

SITE INFORMATION

Site Name: _____ Municipality: _____
Project Number: _____ County: _____
Personnel: _____ State: _____
Date: _____ Street or Map Location: _____
(If Off-Site): _____

WEATHER CONDITIONS AND EQUIPMENT

Temperature Range: _____ Equipment No.: _____
Precipitation: _____ Equipment Number: _____
Barometric Pressure: _____ Latest Calibration Date: _____
Tidally-Influenced ☐ Yes ☐ No

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

TtNUS Form 0010

* measured made to 0.00 feet



TETRA TECH NUS, INC.

WELL INSPECTION AND GROUNDWATER LEVEL
MEASUREMENT SHEET

WELL NUMBER: _____

PROJECT NAME: _____

DATE/TIME: _____

PROJECT MANAGER: _____

INSPECTED BY: _____

VENT WELL

MONITORING INSTRUMENT READING: _____

LEL/O2 READING: _____

WELL INSPECTION/GROUNDWATER LEVEL MEASUREMENT

WELL DEPTH (FEET FROM TOP OF PVC) _____

WATER LEVEL DEPTH (FEET FROM TOP OF PVC) _____

WELL STICK-UP _____

CASING STICK-UP (FEET) _____

WELL DIAMETER (INCHES) _____

WELL CONSTRUCTION (PVC, STEEL, ETC.) _____

LOCKED UPON ARRIVAL? YES NO

LOCKED REPLACED? YES NO

OBSTRUCTIONS? YES NO

WELL RELABELED? YES NO

SLUG TEST CONDUCTED? YES NO (If YES, refer to "Hydraulic
Conductivity Testing Data
Sheet")

GENERAL CONDITION/COMMENTS: _____



JAR HEADSPACE ANALYSIS LOG

SITE NAME:

SITE LOCATION:

PROJECT NO./CTO NO.:

SAMPLE LOCATION:

INSTRUMENT:

SERIAL NÓ.:

MODEL NO.:

SAMPLE PREP METHOD¹

HEADSPACE ANALYST:

DATE:

[illegible]

NUS Form 0008

- 1) (a) ambient temp
(h) heated (air)
(w) hot water bath

- 2) Type of Sample
SB Soil Boring
SD Sediment Sample

GW Groundwater Sample
TP Test Pit Sample

SS Soil Sample



SAMPLE LOG SHEET - "LOW FLOW" GROUNDWATER

Site Name: _____
Sample ID: _____

Tetra Tech NUS Job No./PMS _____
QC: _____ **(If applicable)**

Sample Method: _____
Depth Sampled: _____ **Feet** **Screened Interval Depth** _____ **feet**
Sample Date & Time: ____/____/____ _____ **hours** ____/Dup
Sampler(s): _____
Data Recorded By: _____ **Signature:** _____
Notes: _____

H&S Survey Meter _____ PPM Field Instrument Group A/B/C/D
Pre-pump insertion WL _____ ft Post - pump insertion WL _____ ft

Analysis	Bottle Lot#	Analysis	Bottle Lot #	Analysis	Bottle Lot #
----------	-------------	----------	--------------	----------	--------------

[illegible]

1. Pump dial setting (for example: hertz, cycle/min, etc.)
2. Siemens per cm (same as umhos/cm) at 25 °C.
3. Oxidation reduction potential (stand in for Eh).

Tt NUS Form 0009



SAMPLE LOG SHEET - "LOW FLOW" GROUNDWATER

Site Name: _____
Sample ID: _____

Tetra Tech NUS Job No./PMS _____
QC: _____ **(If applicable)**

[illegible]

1. Pump dial setting (for example: hertz, cycle/min, etc.)
2. Siemens per cm (same as umhos/cm) at 25 °C.
3. Oxidation reduction potential (stand in for Eh).

Tt NUS Form 0009



TETRA TECH NUS INC.

FIELD MODIFICATION RECORD

Site Name: _____ Location: _____

Project Number: _____ Task Assignment: _____

To: _____ Location: _____ Date: _____

Description: _____

Reason for Change: _____

Recommended Action: _____

Field Operations Leader (Signature): _____ Date: _____

Disposition/Action: _____

Project Manager (Signature): _____ Date: _____

Distribution:	Program Manager:	_____	Others as Required:	_____
	Project Manager:	_____		_____
	Quality Assurance Officer:	_____		_____
	Field Operations Leader:	_____		_____
	Project File:	_____		_____